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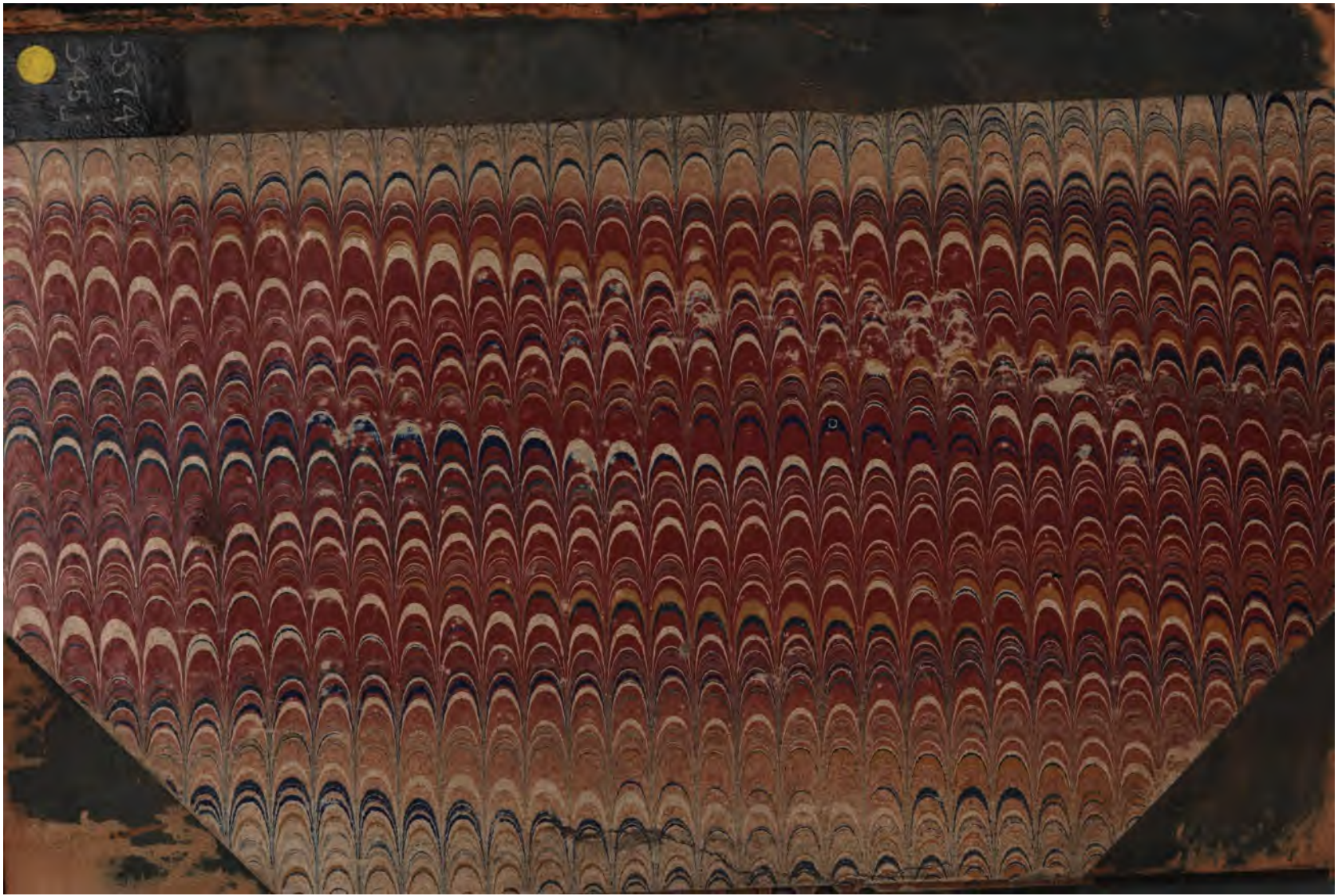

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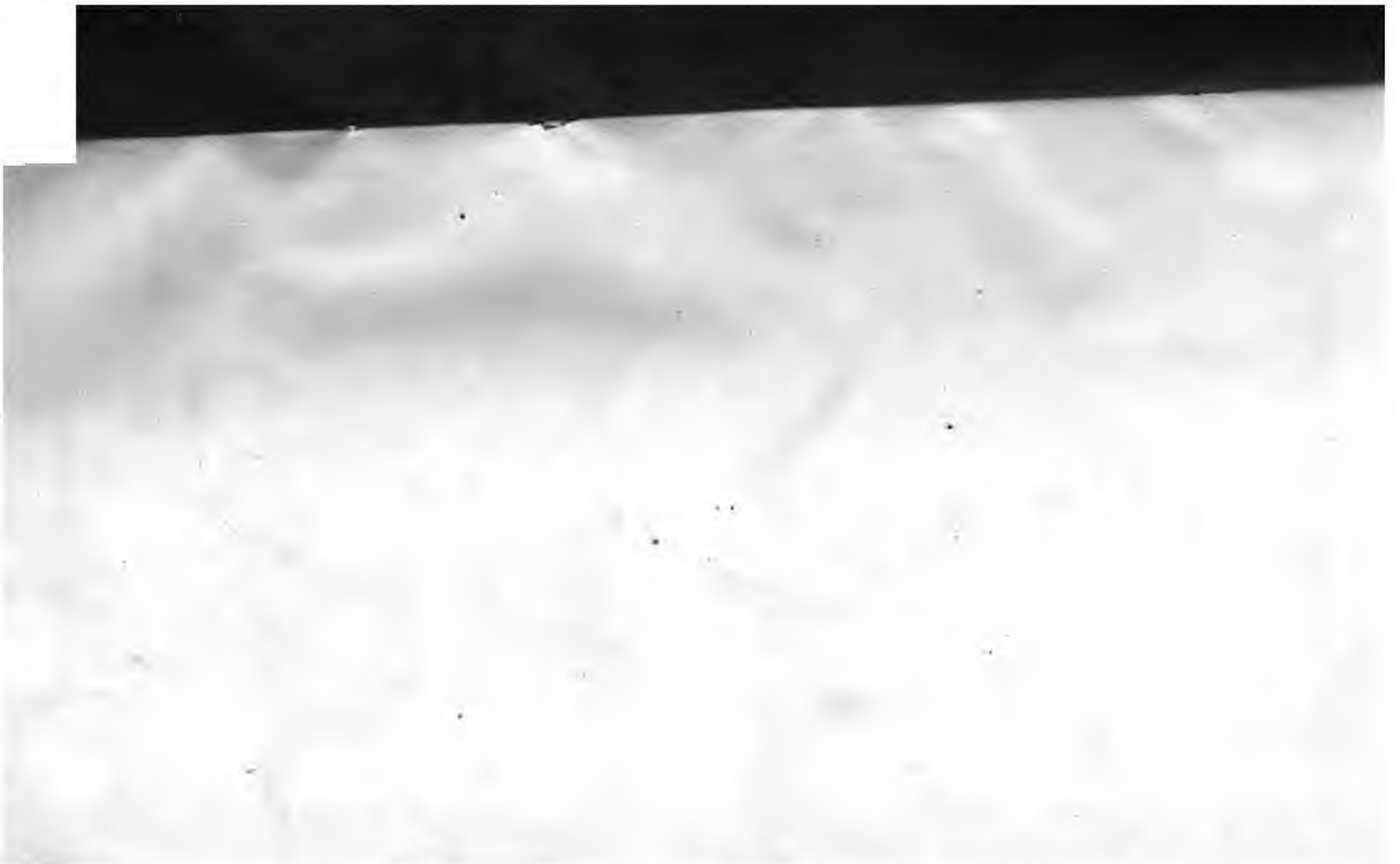

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THE

MINERAL WEALTH,

CLIMATE AND RAIN-FALL,

AND

NATURAL RESOURCES

OF THE

BLACK HILLS OF DAKOTA.

BY

WALTER P. JENNEY, E. M.,
GEOLOGIST-IN-CHARGE.

DEPARTMENT OF THE INTERIOR,
OFFICE OF INDIAN AFFAIRS,
1876.

UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY
OF THE BLACK HILLS.

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LETTER

FROM THE

SECRETARY OF THE INTERIOR,

TRANSMITTING,

In answer to a Senate resolution of April 18, 1876, *a copy of the report of Prof. Walter P. Jenney upon the agriculture, climate, and resources of the Black Hills.*

APRIL 24, 1876.—Referred to the Committee on Printing.
APRIL 25, 1876.—Ordered to be printed.

DEPARTMENT OF THE INTERIOR,
Washington, April 21, 1876.

SIR: I have the honor to acknowledge the receipt of the following resolution, passed by the Senate April 18, 1876:

Resolved, That the Secretary of the Interior be requested to furnish a copy of the report, dated April 15, 1876, of Prof. Walter P. Jenney upon the agriculture, climate, and other resources of the Black Hills, which he surveyed under orders of the Commissioner of Indian Affairs.

In answer to said resolution, I transmit herewith copy of report, dated the 20th instant, from the Commissioner of Indian Affairs, together with chapters V, VI, and VII of the final report of the exploration of the Black Hills country, made by Professor Jenney, which contains the information called for by the said resolution.

I have the honor to be, very respectfully, your obedient servant,

Z. CHANDLER,
Secretary.

The PRESIDENT *of the Senate.*

DEPARTMENT OF THE INTERIOR,
OFFICE OF INDIAN AFFAIRS,
Washington, April 20, 1876.

SIR: In compliance with Senate resolution of the 18th instant, which I had the honor to receive by Department reference of the 19th instant, and herewith return, I forward a report of Walter P. Jenney, E. M., of date the 15th instant, upon the mineral wealth, climate, rain-fall, and natural resources of the Black Hills.

I have the honor to be, very respectfully, your obedient servant,

J. Q. SMITH,
Commissioner.

The Hon. SECRETARY OF THE INTERIOR.

WASHINGTON, *April* 15, 1876.

SIR: In view of the existing popular interest in this subject, I have the honor to submit herewith a report upon the mineral wealth, climate, rain-fall, and natural resources of the Black Hills, the same being chapters V, VI, and VII of my forthcoming final report of the survey executed under instructions of the Commissioner of Indian Affairs of March 27, 1875.

Very respectfully, your obedient servant,

WALTER P. JENNEY, E. M.,
Geologist Exploration of the Black Hills.

HON. J. Q. SMITH,
Commissioner of Indian Affairs, Washington, D. C.

REPORT

ON THE

MINERAL WEALTH, CLIMATE, AND RAIN-FALL,

AND

NATURAL RESOURCES,

OF THE

BLACK HILLS OF DAKOTA.

BY

WALTER P. JENNEY, E. M.,

BEING

CHAPTERS V, VI, AND VII OF THE FORTHCOMING FINAL REPORT OF THE EXPLORATION OF THE BLACK HILLS, MADE UNDER THE DIRECTION OF THE COMMISSIONER OF INDIAN AFFAIRS IN 1875.

CHAPTER V.

MINERAL RESOURCES.

SECTION I.

INTRODUCTION.

The Black Hills of Dakota are included between the Belle Fourche and the South Fork of the Cheyenne River, extending in a direction north 20° west for one hundred and twenty miles, with a breadth of from forty to sixty miles. They cover an area of nearly six thousand square miles, two-thirds of which is in Dakota, the remainder in Wyoming, the boundary-line between these Territories, the hundred and fourth meridian of longitude, passing through the western portion of the area. Surrounded on every side by level or rolling plains and separated from the main chain of the Rocky Mountains, the Black Hills have a geological system perfect and complete in itself, with the records beautifully preserved in the rocks, and each successive formation fully exposed by uplift and erosion to scientific investigation.

Conceive a nucleus of upturned metamorphic rocks, mica-schists, slates, and quartzites of Archæan time, surrounded by encircling-belts of the subsequent geological formations, extending continuously around the Hills, arranged in the order of their deposition, with a general dip from the center toward the level plains.

The mineral wealth of the Black Hills is derived from these Archæan rocks; distorted, set on edge, and metamorphosed, they contain the auriferous quartz-ledges, and these, by decomposition and erosion, have yielded the gold to the placer-gravels. Covering an area of about nine hundred square miles, the metamorphic rocks are discovered, on examination, to naturally separate themselves into two distinct divisions, the *schists* and the *slates*. The schists, usually micaceous, occupy the southwestern portion of this area, reaching from Castle Creek southeastwardly, through Custer's Park and the Harney's Peak range, to the southern end of the Hills. The clay-slates and quartzites extend in a parallel belt from the extreme northern part of the main range of the Black Hills, near Crow Peak, to a point nearly east of Harney's Peak, a few miles from the edge of the plains. The slates are probably more recent in age, and rest unconformably on the schists, though both formations have been subjected to simultaneous folding and metamorphic action until the contact between them is very indistinct and difficult to identify. Among the rocks of the first division immense masses of white feldspar-granite have been intruded between the strata of schists, especially in the southeastern portion of the hills, where the Harney's Peak range, eight miles in length and two to four miles in width, is wholly made up of this granite. Narrow dikes of granite traverse the schists conformably to the stratification. The sides of these dikes often expose black, polished surfaces or slickensides. In places the plastic granite in its intrusion has completely inclosed huge fragments broken from the adjacent schists.

In the northern section of the Black Hills numerous dome and angular shaped peaks are formed by the injection of trachyte through the slates and the superincumbent strata of as late an age as the Cretaceous, locally metamorphosing the sedimentary formations, until the altered rock cannot be distinguished by the eye from the genuine trachyte. These trachytes contain gold disseminated through the mass of the rock, and by decomposition and erosion have furnished a large proportion of the gold contained in the gravel-deposits of the streams draining that area.

The next succeeding geological formation, the Potsdam sandstone, 250 feet in thickness, lies uncomformably on the upturned edges of the Archæan strata. The lower layer of the Potsdam is a coarse conglomerate of water-worn and rounded bowlders derived from the older schists and slates on which it rests. In it we find large bowlders of quartz, ferruginous, banded, or slaty in character, exactly as it occurs in the adjacent ledges traversing the slates, intermixed with pebbles and bowlders from all the harder rocks in the vicinity. This conglomerate tells in unmistakable terms that the Archæan rocks were deposited, upturned, and folded, the quartz-ledges, with the gold and minerals which they contain, formed, and the whole formation subjected to an immense denudation before the first strata of the Potsdam were laid down on the bottom of the Silurian sea. The auriferous quartz-ledges in the schists and slates do not extend beyond the eroded surface of the metamorphic rocks or enter strata of the Potsdam or any succeeding geological formation, and the filling of the gold-bearing quartz-veins most probably occurred during the folding of the inclosing rocks at the close of the Archæan period. The Potsdam conglomerate, composed of the material resulting from the denudation of the quartz-ledges in the Archæan rocks, probably contains gold, and, by decomposition, yields it to the placer-gravels. But, with this exception, the sedimentary rocks in the Black Hills, from the Potsdam to the Cretaceous, are devoid of metallic wealth. The remaining portion of the Potsdam formation, resting on the conglomerate, is made up of lamellar sandstones and sandstone-shales, containing ripple-marks, impressions of sea-weeds, and layers honeycombed by the borings of marine worms—evidence of deposition in a shallow and advancing sea. On reaching the top of the Potsdam, the Carboniferous formation is encountered; a dark-brown calcareous sandstone, about 25 feet in thickness, containing fossils of that age, rests exactly conformably on the upper layers of the Potsdam without the slightest indication that nearly all the Silurian and the whole of the Devonian periods have intervened between the deposition of these two beds of sandstone.

On this sandstone is built up the massive white limestone of the Carboniferous, forming cliffs 300 to 400 feet in height, overlaid by a calcareous sandstone, variegated in color, of nearly equal thickness, also deposited during the Carboniferous period, when the whole area embraced in the Black Hills was buried deep beneath the waters of the ocean, and the Carboniferous strata extended in an unbroken sheet over the present area of the gold-field, which by elevation and denudation has been subsequently uncovered to view. We know this because the cliffs of limestone completely inclose the area of Archæan rocks, showing no thinning out at the edges except from erosion, and tower far above the surface covered by the schists and slates.

Crook's Tower, one of the highest points in the hills, having an altitude of 7,323 feet above the sea, is formed of this limestone, and, though *having lost* several hundred feet of Carboniferous sandstone by denuda-

tion, is only about 80 feet lower than the summit of the granite of the Harney's Peak range.

The Carboniferous formation is the most extensive in the Black Hills, covering nearly fifteen hundred square miles, almost one-half the timbered surface, and, though equivalent in age to the coal-measures of Pennsylvania and the Mississippi Valley, the occurrence of a deep sea over the whole of this area during the continuance of the period precludes the formation of any true coal-beds in this region.

Tertiary or Cretaceous lignites of inferior quality were discovered, however, along the Cheyenne River, to the southwest of the Black Hills.

The "Red Beds" form the next succeeding belt to the Carboniferous, so called from the vermilion-color of the sandy clays, a constant feature in this formation in the western country from Texas to the British Possessions.

Barren of all evidences of life, from position they are supposed to be of Triassic age, being included between well-marked Carboniferous and Jurassic. In the Black Hills they consist in an ascending order of 100 feet of coarse red sandstone, 40 feet of impure pinkish limestone, and 300 feet of red sandy clays, interstratified with white massive gypsum. From their soft and clayey character, and the presence of the strata of gypsum, the Red Beds yield readily to erosion and atmospheric agencies, and their outcrop is marked by a broad red valley entirely encircling the Black Hills at the edge of the plains, forming a prominent feature in the topography of this region which the eye easily traces by the brilliant color of the soil for miles along the foot-hills.

Beyond the Red Beds are 200 to 500 feet of white and colored clays and soft sandstones of Jurassic age, interesting scientifically from the abundance of fossil-shells found in them, but not at all prominent in the formation of this region, except in the Bear Lodge range, in the northwestern part of the hills, where the Jurassic covers an extensive area.

Resting on the Jurassic are the Dakota sandstone and the lead-colored clays and clay-shales forming the different members of the Cretaceous, spreading over an enormous area of the plains surrounding the Hills.

The Cretaceous closes the geological formation represented in the Black Hills by sedimentary strata of marine origin. No well-marked Tertiary occurs within its limits, but fresh-water deposits of that age are found on the Cheyenne, some fifteen miles southeast of the hills.

From the Potsdam to the top of the Cretaceous the formations are perfectly conformable to each other in their deposition, showing that no disturbance of the strata occurred during that time, and that the rocks of the different ages were nearly horizontal until the elevation of the Black Hills took place, and the trachyte forming the peaks in the northern part of the range was ejected through the slates and overlying strata.

In the valley of the Cheyenne, between the top of Cretaceous No. 5 and the base of the White River Tertiary, a conglomerate occurs, about 6 feet in thickness, containing pebbles from all the harder rocks now found in the Black Hills, indicating that the geological formations existed during the Tertiary period nearly as we find them at the present time in the Hills.

The conformability of the strata and the absence of Tertiary formations in the Black Hills would not be alone enough to fix definitely the date of the elevation of the range as occurring after the close of the Cretaceous and before the deposition of the Tertiary, were it not corroborated by observations on the unconformability of the Tertiary and

older formations at the head of Old Woman's Fork, and by the results of the work of other explorers in the Rocky Mountain system.

From the elevation, the horizontal formations assumed the shape of an immense flat-topped anticlinal arch spanning nearly sixty miles, which, cut down and planed off by subsequent erosion to its center, exposes the edges of the different strata as annular rings surrounding the metamorphic interior, thus giving to the Black Hills at the present day the appearance of an island formation with a central granitic nucleus encircled by the successive geological formations, built on like shore-deposits one beyond another from the Archæan to the Tertiary. This great erosion which has taken place since the elevation of the Hills has produced the material forming the placer-gravels and liberated the gold which they contain from the inclosing rocks and ledges. In part it is probably due to the agency of ice and water during the Drift or Glacial period, but apparently the erosion is mostly the result of the action of the present streams and system of drainage.

The exact date at which the intrusion of the granite forming the Harney's Peak range took place is as yet undetermined. The coarsely crystalline character of the granite indicates a very slow and gradual crystallization, requiring a length of time which only the untold ages of the Archæan could furnish. It must have occurred either before the Potsdam or at the time of the elevation of the hills at the close of the Cretaceous, as the conformability of the strata would have been disturbed had the intrusion taken place during the intermediate time.

No bowlders or pebbles of this granite were found in the Potsdam conglomerate, though we searched for it in many places. The whole surface of the country is covered by granite bowlders resulting from the more recent erosion of the Hills, and the conglomerate between the Cretaceous and Tertiary on the Cheyenne is largely made up of material derived from the granitic rocks.

Possibly the absence of granite in the Potsdam conglomerate may be caused by its more readily yielding to the decomposing effect of atmospheric agencies during the Archæan and Silurian periods.

By reference to the colored geological map of the Black Hills accompanying this report, the area and position of the different formations can be readily seen. The rocks of each age, where exposed to view, are represented by an appropriate tint covering a corresponding area on the map.

The miners, for convenience in making laws to govern the recording and locating of claims, have divided the gold-field into different districts, which division I shall follow as closely as possible in considering the value and character of the gold-deposits in the Black Hills.

SECTION II.

THE FRENCH CREEK DISTRICT.

In the French Creek district is embraced all the area of granitic and schistose rocks surrounding Harney's Peak and forming the southern portion of the Hills, bounded by Spring Creek on the north, and including the placer-gravels in the valleys of Wiwi Creek, Custer's Gulch or French Creek, Amphibious, Minnekata, and Red Cañon Creeks, streams draining this region and emptying into the South Fork of the Cheyenne.

Before discussing the value and extent of the gold-deposits, it is necessary to describe briefly the topography and geological formation of

this district, which presents, in the immense development of granitic rocks, a feature peculiar solely to this section of the Black Hills.

The Harney's Peak range, and the country included between it and the foot-hills on the eastern slope, is an exceedingly rugged and mountainous region, heavily wooded with pine and cut into innumerable deep ravines by a net-work of small streams flowing in a general southeasterly direction, but sinking before they reach the plains. These small creeks are full of beaver-dams, and the bottoms of the gorges are overgrown with a perfect jungle of oak, elm, birch, elder, and grape-vines, making it almost impossible to descend the valley of the stream, and compelling the explorer in this wilderness to travel across the steep and broken rocky ridges, where, except he be fortunate enough to climb some of the few commanding peaks, he cannot see but a short distance in any direction, owing to the densely-wooded and broken character of the region. It is useless to look for any main divide which can be followed in traversing this mountainous section; the whole area is broken into innumerable granite peaks and ridges without any apparent system whatever, except that the drainage is in a general southeasterly direction toward the open plains. The effects of erosion are everywhere strongly marked, and the peculiar topography of the region is due to the resistance of the hard granite and the yielding of the micaceous schists to the action of time and water.

The prominence of the granite, which in huge, serrated ridges rises on every side, is due more to erosion than to any elevation caused by its intrusion; yet the granite, though so unyielding, shows by the rounded and pinnacled forms assumed by the peaks, that time has affected it as well, but in a less degree.

To the northeast of Harney's Peak is an area of slates, which properly belongs to the Spring Creek district, but with that exception this section is almost universally granitic, the schists, wherever they occur, being concealed by the *débris* resulting from the denudation of the granite ridges that tower far above the surface of the softer rocks.

Harney's Peak, having an altitude of 7,403 feet above the sea, is the culminating point of this great intrusion of granite, and forms the most conspicuous landmark in the Black Hills, visible from the plains to the south and east for a distance of more than fifty miles from the foot-hills.

The Park region, at the west and southwest of Harney's Peak, is a most agreeable contrast to the inaccessible wilderness to the east. Broad glades of level grass-land extend between the parallel ridges of granite and groves of pine cover the rocky hills wherever there is sufficient soil to support their growth. Isolated peaks of granite, rounded by erosion and weathering into dome-shaped and castellated forms, rise from the open and level surface, which everywhere is carpeted with the finest grass, giving a beautifully picturesque and park-like scenery to the region.

The smooth surface of the parks and the peculiarities in the topography are due to the parallel ridges of granite resisting the denudation, which has excavated the broad swales in the intervening softer schists, and indicates that the orginial surface of the formation was far above the present level.

The granite is conformable to the stratification of the inclosing schistose rocks, having been intruded between the layers, the only direction in which the micaceous rocks are readily fractured. This conformability is not perfect, as it would be were the granite the result of metamorphic action on a layer of the schists, but the granite ridges often occur

traversing the park as a broken range of lenticular peaks on the same line of fracture, resembling, on an enormously-magnified scale, a well-known form of segregated quartz-veins. Narrow dikes of granite traverse the schists, often not more than two or three feet in width and of regular thickness, continuing uniformly for several hundred yards parallel to the stratification, and being harder than the schists, have been left by erosion standing like walls several feet above the surface of the ground. Where the surface of contact of the granite and the schists is exposed, the sides of the dike are seen to be smooth surfaces, often beautifully marked with slickensides exceeding in the polished and striated markings any specimens of the walls of mineral veins which have ever come under my notice.

The sides of the lenticular masses of granite forming the low ridges show slickensides and vertical striated surfaces, but not nearly in so marked a degree as the narrow dikes.

The granite is very coarsely crystalline, largely composed of white or flesh-colored feldspar, intermixed with quartz and mica, (muscovite,) with black tourmaline in large hexagonal crystals as an associated mineral. Quartz occurs disseminated through the mass of the feldspar in small grains and in nodules between the crystals. Segregated veins and irregular masses of quartz occur in the granite ridges, generally white, vitreous, or translucent, frequently of a beautiful deep rose-color, but everywhere apparently free from any traces of valuable minerals, or any considerable quantity of gold.

The schistose rocks are in great variety, mica-schist being the prevailing form, often garnetiferous, and merging into talcose, chlorite, and quartz schists.

The minerals found in the schists are few in number. Small garnet-crystals are very abundant; a few specimens of hornblende, epidote, and staurotide were seen, but they occur but rarely in these rocks. Veins and ledges of ferruginous quartz are found traversing the schists between the granite ridges or dikes to which they are parallel. These ledges are not *true fissure-veins*, that is, they do not intersect the strata at an angle to the stratification, neither are they segregated veins, but occur filling continuous and regular fissures between the lamellæ of the schists formed in the folding of the rocks, and are in fact *interlaminated* fissure-veins.

The quartz is often mixed with a large proportion of brown and yellow oxides of iron, resulting probably from the decomposition of pyrites, and the gold now found in the gravel-deposits along the streams has been derived from the disintegration and denudation of these ledges in the schists.

But little prospecting could be done in the numerous quartz-veins of this district, for want of time and proper tools. The miners reported gold in small quantities from several veins which they discovered and opened.

Near the stockade on French Creek a mass of schist was noticed, about 150 feet in length, upturned on edge and completely inclosed by a broad rim of granite. This fragment of schist was traversed by a ledge of quartz and limonite several feet in width, conformable to the stratification, and cut off at each end by the subsequent intrusion of the granite. From the uniformity in the composition and appearance of the granite from all parts of the Harney's Peak range, the dike character of the ridges, the presence of slickensides, and the observed instances of inclosed fragments of schists, I can but regard the granite of this *region as injected*. There are occurrences of small, narrow veins of

feldspar leading from the granite into the schist, probably deposited by chemical solutions accompanying the intrusion, which would seem to indicate that the fluidity of the injected granite was due more to the presence of water than to the intensity of the heat.

French Creek rises in the level park country southwest of Harney's Peak, among granite, gneiss, and schistose rocks, and flows in a general easterly and southeasterly course about fifteen miles, until, entering a deep cañon in the limestone formation, it sinks among the bowlders in the bed of the channel and disappears before reaching the foot-hills, continuing as a dry arroyo, with water-holes at intervals, to the Cheyenne. Near its head it is a sluggish stream with long stretches of slack-water; in midsummer, notwithstanding frequent showers of rain, drying up to a chain of water-holes. A few miles below the stockade it is swelled by springs and side branches to a creek 10 to 15 feet in width and about 8 to 12 inches deep, flowing with a moderately-rapid current until it is lost in the cañon.

Gold was discovered in gravel-bars on French Creek early in August, 1874, by Ross and McKay, miners accompanying the expedition under command of General G. A. Custer, but from want of time they were unable to ascertain definitely whether the gold existed in paying quantities, although obtaining by a few days' work quite encouraging prospects.

About three weeks later this field was visited by the Rev. S. D. Hinman, with an escort from the agencies on White River, in search of a suitable location for a reservation, but not finding any evidences of gold, on their return they threw some discredit on the reports of the existence of the precious metal in the Black Hills.

A party of twenty-five miners from Sioux City reached French Creek December 23, 1874, and built a stockade and cabins near the location of General Custer's camp. They passed the winter prospecting very industriously for gold in the vicinity, opening several quartz-ledges in the schistose rocks of the park, and sinking pits on the flats and gravel-bars along the stream.

Before cold weather was over and the frost out of the ground so that the diggings could be opened on a scale large enough to practically test the richness and extent of the gravel-deposits, these miners were removed by the military to Fort Laramie.

When (June 16) I reached French Creek, about fifteen miners were found camped four miles above the stockade, where they had been at work for several weeks, and had staked off claims, built small dams, and were digging ditches preparatory to commencing sluicing on the bars along the banks of the stream. These miners were very enthusiastic in regard to the mineral wealth of the gulch; they were reporting from 5 to 27 cents to the pan from the pay-gravel, and made the most extravagant statements as to the yield which would be obtained as soon as they commenced working with sluices. But they were working under unfavorable circumstances; the water-supply was very small, not exceeding 50 miners' inches, with every indication that it would soon fail entirely, and the grade of the valley was so small that it was difficult to get a good head of water for sluicing. On testing, by washing, the pay-gravel from the different prospecting holes already opened, with a pan, and weighing the gold obtained, it was found that the usual yield along the stream was from four to eight colors to the pan, (about one-tenth to one-fifth of a cent,) and, in favorable and somewhat limited localities, from half a cent to as high as one and a half cents were obtained from the gravel from off bed-rock. The gravel-bars were rich enough in gold to pay, if extensively worked under more favorable cir-

cumstances, but too poor to yield a remunerative return for the labor employed, except in a few limited deposits of gravel near the extreme head of the stream.

The next day the following dispatch, embodying all the information in regard to the gold-field that had been obtained to date, was sent by courier to Fort Laramie and telegraphed to Washington:

CAMP ON FRENCH CREEK, NEAR HARNEY'S PEAK,
June 17, 1875.

To Hon. E. P. SMITH,
Commissioner of Indian Affairs, Washington, D. C.:

I have discovered gold in small quantities on the north bend of Castle Creek, in terraces or bars of quartz gravel.

Arrived here yesterday. About fifteen miners have located claims on the creek above here, and have commenced working. Gold is found from Castle Creek southwardly to French Creek at this point; the deposits are almost wholly in Dakota. The region has not been fully explored, but the yield of gold thus far has been quite small, and the reports of the richness of the gravel-bars are greatly exaggerated.

On French Creek the deposits of gravel are very unfavorably situated. The water-supply is small and failing, and the grade too little to admit of the tailings being carried off by the stream.

The prospect at present is not such as to warrant extended operations in mining.

WALTER P. JENNEY, E. M.,
Geologist Exploration of the Black Hills.

The fact of the existence of gold caused considerable excitement among the soldiers and teamsters of the escort, and quite a number were busily engaged in prospecting along the creek, sinking holes to the bed-rock wherever there was the slightest indication of a deposit of gravel, or cleaning out old prospecting-shafts dug by the miners the preceding winter, and panning the pay-gravel which had been reported to be so rich in gold. But the results of their labor were so discouraging—generally only a few small "colors" would be obtained from a pan of gravel, and rarely more than three-quarters of a cent to the pan in the richest layer of pay-dirt from off bed-rock—that after a few days they abandoned the search for the precious metal and did not resume it for more than two weeks, until the discovery of a very encouraging prospect on a bar near the stockade caused a renewal of the excitement for a time, an account of which will be given farther on.

In examining the gravel-deposits along the valley of French Creek, advantage was taken of the numerous prospecting shafts already sunk by the miners, and in the few places remaining untried which gave any indication on the surface of the existence of valuable underlying gravel-beds, shafts were sunk to bed-rock by the miners assisting me in the work. The first tests were made by washing several pans of the pay-gravel in the usual manner, and if the result obtained was at all encouraging, the deposit was more extensively tested by washing a measured quantity of the pay-dirt in a rocker and weighing the gold obtained. Finding that the best prospects in the gulch were from gravel from a prospecting shaft on a dry branch of French Creek, about five miles above the stockade, the following test was made to determine as accurately as possible the richness of the deposit:

The shaft was first cleaned out and a sufficient quantity of the pay-gravel drifted out from off bed-rock, carefully averaged, measured, and washed with the greatest care in a rocker, every precaution being taken to prevent any appreciable loss of fine gold carried over the riffles by the muddy water. The result was as follows: 9 buckets gravel = 3.12 cubic feet, gave 0.370 gram. of gold in small flat scales and grains:

0.370 gram. = 5.7 grains troy = $0.23, or about one and one-fourth cents to the pan.

This would indicate a yield of $1.87 per cubic yard of the pay-gravel which formed a layer on bed-rock about a foot in thickness.

In the above calculation an average bucket of gravel is taken at 600 cubic inches, or 75 buckets equal one cubic yard. A pan is about half a bucket, giving 150 pans of dirt to a cubic yard. I have estimated the value of the gold to be $19.50 per ounce in gold coin.

The gravel from a shaft some distance below on the stream, tested in a similar manner, gave the following result: 10 buckets dirt = 3.42 cubic feet, yielded 0.020 gram. gold; 0.020 gram. = 0.3 grains troy = 0.012 cent, or 9 cents per cubic yard, equal to one-twentieth of a cent to the pan. This latter gravel was very poor in gold, but that washed in the preceding test was correspondingly richer than the average of the gravel opened at that time along the creek. Near the stockade the result of the prospecting showed that the richest gravel was from a hole sunk to bed-rock on the bank of the creek, four pans of the pay-dirt giving ¾ grain troy = 3 cents gold, or ¾ of a cent to the pan. Washing 12 buckets of this gravel in a rocker, yielded 4¼ grains troy of gold = 17 cents, or $1.12 per cubic yard; nearly the same result as was obtained with the pan.

Most of the prospecting holes had been sunk early in spring, when the ground was full of water and the locations selected with regard to the rim-rock, so that the bed-rock might be reached before the depth of the shaft became so great that it would be flooded with surface-water. In order to test the deeper channels in the flats near the stockade, a place was selected where the configuration of the surface of the ground indicated an old channel filled with gravel to the present surface of the bar.

A shaft 5 feet by 7 feet was sunk to bed-rock, which was reached at a depth of 15 feet, passing through gravel filled with large water-worn bowlders 2 to 3 feet in diameter. Four men were constantly employed for three days in sinking this shaft; the bowlders had to be broken with sledges and hoisted out with a windlass, and the water was so troublesome as to require constant bailing to keep the shaft dry. The bed-rock was found to be granite. On cleaning up the whole surface the size of the bottom of the shaft and panning the gravel, not a color of gold was obtained, a result which was unlooked for by the miners, the gravel passed through having been quite promising in appearance.

Having forwarded to Washington a written report embodying the results of the prospecting and exploration made up to date, (June 25,) I left French Creek, and, accompanied by my miners, made an excursion north, for the purpose of examining the valleys of Spring and Rapid Creeks, and on my return, July 8, I found that some new discoveries had been made, and considerable work done by the miners in my absence.

A party of miners about five miles above the stockade had put in a small sluice, and reported that they obtained by one day's work 27 pennyweights of gold, or nearly $27; three men being employed in shoveling the gravel into the sluice. Unfortunately, the work on this bar was stopped by the stampede to the new discoveries in Spring and Castle Creeks, before it could be thoroughly tested and the richness of the deposit proved to be constant and regular.

John W. Allen, of Cheyenne, an experienced miner, and one of the best prospectors I ever knew, in a letter to the Chicago Inter-Ocean, gives the results of this sluicing, in which he assisted the owners of the bar.

CHEYENNE, WYOMING TERRITORY,
August 30, 1875.

To the Editor of the Inter-Ocean:

* * * * * * *

I waited last spring for the country to be thrown open by this Indian treaty now pending, and becoming impatient I concluded to do as hundreds of others did, to start into the hills, and on the 12th of July landed in Custer's Park, and being an experienced miner, I had doubts in regard to French Creek paying, because of there being no fall to the creek and scarcely any water. But I found one set of sluice-boxes about to be set up, and I went to work and helped to fix them, and then worked one day and weighed the dust, and found that the ground paid $9 per day to the hand, of fine dust, although am sure this creek will not average that all the way through the gulch.

* * * * * * *

JOHN W. ALLEN.

John Roberson, an old California miner of the "days of forty-nine," had discovered very good prospects on an elevated bar near the stockade, and, building a dam, conveyed the water from the creek in a small ditch to the face of the drift. In the mean time the soldiers had become quite excited over the discovery, and were hard at work with pans and rockers, washing the pay-dirt from off bed-rock. For several days they were quite successful. From 16 to 26 colors were obtained to the pan. One soldier found a piece of gold valued at 20 cents; another a small nugget weighing about a pennyweight, worth 97 cents, and 24 buckets of gravel gave, on washing, an average of 12 cents gold. On drifting in on the bar the pay-streak rose, and was found among the bowlders nearly 18 inches above the bed-rock. The section of this gravel-deposit was as follows:

Soil	1 foot.
Gravel and bowlders	4 feet.
Clayey compact gravel containing the gold	6 inches.
Decomposed bed-rock and bowlders	1 foot.

Micaceous schist forming bed-rock.

The sluices were soon in place, and this bar most thoroughly tested, under the direction of Mr. Roberson. The result of the first day's work of eight hours, four men being employed most of the time, was 2 dwt. 8 gr. Troy of coarse gold, valued at $2.30.

The second day, not only the gravel was put through the sluce, but the whole surface of the bed-rock exposed by both days' work was most carefully cleaned up and washed. The return, however, was but 1 dwt. 9 gr. Troy of gold, equal to $1.10.

The work of both days may be summed up:

4 men 1 day, result	$2 30
6 men 1 day, result	1 10
10 men 1 day, result	3 40

or a yield of 34 cents per day per man.

This result was a disappointment to every one, and seemed to indicate that the richness of the gravel at first obtained was due to a concentration of the gold on rim-rock, and that the cleaning of the bed-rock probably yielded only a very small proportion of the gold, the greater quantity being derived from the compact gravel.

The gold obtained was in coarse, flat scales, or small, spongy grains, and was quite deceptive in its appearance, nearly all the miners guessing the weight of the dust very much too high.

Gold was found in small quantities in gravel deposits along the numerous creeks flowing east from Harney's Peak, but the region is so *inaccessible*, and so many difficulties are encountered in attempting to

prospect it, that but little could be done by myself and assistants in that area, while the rush to the discoveries on Spring and Castle Creeks carried all the miners in the hills far to the north, and left this region but partly prospected.

Some prospecting was done on Amphibious, Minnekata, and Red Cañon Creeks, small streams draining the southern portion of Custer's Park. On Amphibious, near its headwaters, a few colors of gold were obtained from small gravel-deposits, but the water-supply was so small, the stream being dry at the time, that prospecting was very difficult. About five miles below the head of this creek, a number of dry ravines enter it from the east, cutting deep into the schists and slates. In these ravines float-quartz was found, showing, on breaking, visible particles of gold, but the quartz was not traced to the ledge from which it had been originally derived.

Minnekata or "Hot Water" Creek, so named by the Indians from the warmth of the water, which has a temperature of 74° F., although rising in large warm springs in the Carboniferous limestone, has a deep deposit of quartz-gravel on its east bank, about two miles below its source. This gravel is derived from the wash from the Hills, and is composed of bowlders of rocks and quartz cemented by sand and lime to a loosely cohering conglomerate, forming a bluff on the bank of the stream. Similar deposits are to be seen at intervals among the foot-hills at the edge of the plains all along the eastern slope from this stream as far north as Box Elder.

On Red Cañon Creek several tests were made of the gravel-deposits, but nothing of value found. This stream is on the extreme western edge of the gold-fields, and rises partly in the limestone, contains but little water and drains but a limited area of the schistose rocks.

The gravel-deposits elevated above the present level of French Creek showed often a local concentration of gold on the outer edge of the bed-rock from the repeated washing away of the gravel by floods or heavy rains, leaving the gold contained in it behind. Though giving a very encouraging prospect at first; on driving an open cut a few yards into the bar where the gravel was undisturbed, the richness of the pay-dirt rapidly decreased until it equaled the true average of the whole deposit, thus showing that the result at first obtained was only a "rim-rock prospect."

The richest layer in the pay-gravel was rarely on bed-rock, but usually from 10 to 20 inches above it, forming the upper surface of the stratum of compact clayey gravel mixed with fragments of decomposed bed-rock which had caught and retained the greater portion of the gold.

The gravel-bars along French Creek, for several miles above and below the stockade, were examined wherever there was the slightest indication or probability of gold existing in paying quantities with results similar to those already given, and, as might be expected from the level character of the valley, the gravel-deposits were richest around its head branches, and proved regularly poorer in gold as the distance below its source increased.

Excepting Castle Creek no stream in the Hills was prospected the past season to anything like the extent that the gravel-deposits on French Creek were subjected to. The whole bottom of the valley for nearly six miles was full of prospecting pits. Each new party of miners on arriving in the Hills first visited Custer Gulch, as it was called, and expended their surplus energy and enthusiasm in sinking a number of prospecting holes before proceeding elsewhere in search of gold. But the results obtained by these miners were very poor, except in a few

localities in dry sags and gulches about the head of the creek, and in a limited number of elevated bars along the stream above the stockade.

The gold obtained from the placer gravels on French Creek was in small flattened scales and grains, quite uniform in size, mixed with very little fine dust, and nearly free from magnetic-iron sand. It showed but little action of water, and the garnet-crystals associated with it were often quite perfect and scarcely rounded by attrition. The greater portion of the gold seems to be derived from the quartz-ledges in the schistose rocks and not from the intruded granite, for in side gulches where the rocks were wholly composed of granite, I failed to detect any traces of gold.

The gravel of the placers is a mixture of water-worn quartz mingled with a less proportion of bowlders from all the rocks at present found in the region, including granite and fragments of the harder schists and slates.

The pay-gravel is composed of the heaviest pebbles with some clayey sand and large quantities of red garnet crystals derived from the schists. It is soft, rarely cemented to a conglomerate, and easily washed in a sluice. The layers of the gravel are porous and not clayey enough to be impervious to water, allowing it to pass freely through, and causing considerable inconvenience in prospecting.

The exploration and prospecting on French Creek, both by the geological party and the miners, showed, up to the time I left the gulch, a general diffusion of fine gold in the gravel-beds but little concentrated in the deposits, and found in small quantities throughout the whole breadth of the valley.

The water-supply at the head of French Creek was very small and uncertain, totally inadequate for extensive working of the gulch, while the flatness of the valley is also a serious obstacle to the successful working of the gravel-bars, if water should be brought from Castle Creek for that purpose, which cannot be done until the richer deposits on that creek are exhausted.

Above the stockade there are localities where the gravel will pay fair wages for sluicing, using the limited water-supply of the creek and working only the richest places in the beds. I regard the poverty of the French Creek deposits, compared with those afterward discovered on the streams farther north, to be due to a deficiency in the source of supply, owing to the small area drained by the stream, the small amount of denudation to which the ledges in this area have been subjected, and to a want of sufficient grade in the valley to cause a concentration of the gold into a pay-channel.

Had all the gold diffused through the valley of French Creek been concentrated into a narrow lead or pay-channel, it would have made claims as rich as the most enthusiastic miner would have desired.

SECTION III.

SPRING CREEK DISTRICT.

Spring Creek rises among the parks in the central portion of the Hills, to the west and northwest of Harney's Peak, and is formed by the union of a number of small brooks, some heading in the limestone at the western edge of the Beaver Creek Plateau, others in the granite of the Harney's Peak range, or with numerous ramifying branches drain the schistose rocks of the parks.

Just below where the main branch, flowing from the south, rising

among the granite and metamorphic schists of the parks, unites with Newton's Fork, coming from the talcose and quartz schists in the direction of Castle Creek, a remarkable change is seen in the topography of the region and the character of the rocks; and Spring Creek, becoming a fine and rapid stream, heads eastward into a new geological formation—the second division of the Archæan strata of the Black Hills. We have left to the south and west a region of feldspathic granite, mica schist, talcose and quartz schists, with crystalline or rose quartz, mica, garnets, and feldspar as the characteristic minerals, and enter a parallel belt of massive gray quartzites, argillaceous and siliceous slates, in which the prevailing minerals of the schists are no longer seen.

The change in the character of the rocks produces a corresponding change in the topography of the region; the soft mica-schists had been worn by erosion into broad parks and valleys, intervening with rounded peaks and ridges of the harder strata, but the massive quartzites and hard siliceous slates, resisting denudation, have been left in steep and high rocky hills, through which the stream, winding and twisting among the peaks, has cut a narrow gorge several hundred feet in depth.

This ridge of hard slates and quartzites near the contact of the two formations is an extension of the line of uplift of the Harney's Peak range. Although the granite does not extend as far north as this point by several miles, yet the extreme hardness and uniformity in composition of these rocks enabling them to resist erosion may be in part due to the metamorphic action accompanying the intrusion of the granite forming this range. Following the course of the stream, which soon enters a cañon among the higher peaks of the ridge, the dip of the formation is observed to change from a general westerly direction to a well-marked easterly dip. The sections of the quartzites exposed in the walls of the cañon show a contorted and irregular folding of the strata, but scarcely a quartz-vein of noticeable size occurs in the cliffs, although the composition of the rocks is extremely siliceous; a most decided contrast to the superabundance of quartz distributed through the mica-schists of the older formation about the heads of this stream. Spring Creek, emerging from the cañon, winds through a broad and beautiful valley, bordered by groves of pine for nearly five miles. Long level tracts of fertile bottom-lands, destitute of trees and covered with a rank growth of the finest grass, extend on either bank of the stream, while both on the north and south small open valleys reach far back among the broken and rolling hills, the bright green grass of these glades contrasting strongly with the darker color of the pine-forest covering the slopes and rocky ridges. For nearly twenty miles this stream flows in a general easterly course, crossing the slate and quartzite formation at right angles to the bedding of the strata. Where the hard quartzites predominate in the hills, the creek has cut a deep gorge or cañon through them; but where the softer clay-slates prevail in extensive belts, the stream flows through an open valley, inclosed by low rolling hills and bordered by broad level flats of grass-land. Finally, entering a cañon in the limestone formation near the foot-hills, the water sinks among the bowlders in the bed of the stream and disappears, from whence a dry arroyo, fringed with trees, continues to the plains.

In the Spring Creek district, I include, for convenience of description, all the area of the Hills drained by that stream, and also a district of clay-slates, northeast of Harney's Peak, giving rise to a small branch known as Whiskey Creek, flowing six to eight miles south of Spring Creek, in the same direction, and sinking in the foot-hills.

The head branches of Spring Creek drain an area of nearly one hun-

dred and fifty square miles, elevated about 6,000 feet above the sea, characterized by low, rounded hills, and ridges, wooded with pine of medium size, interspersed with numerous small parks and grassy valleys, well watered by the springs and brooks forming the sources of this stream. The prevailing rocks of this region are mica-schists, often garnetiferous and merging in all gradations into talcose and quartz schist, and strata with thin slate-like lamellæ, containing but traces of mica.

Quartz occurs, distributed abundantly in the schists as thin segregated veins, parallel to the bedding, or in irregular bunches, not continuous in the strata. It is found crystalline, white, red, or rose tinted, and, with the exception, probably, of gold, appears to be free from any other minerals.

The abundance of quartz forms a serious annoyance in prospecting for ledges, the whole country being covered with float-quartz of every variety, rendering it difficult to trace fragments found to contain gold to the veins from which they were derived. The first tests for gold on Spring Creek were made on a small branch flowing west from Harney's Peak and emptying into the main stream about three miles above Newton's Fork. The gravel, resulting from the wash of the granite of the Harney's Peak range, failed to give a trace of gold on panning, but on descending the branch and testing the gravel, as soon as we had entered the mica and quartz schists, small colors of gold were obtained.

The different strata were encountered in the following order, in proceeding down this branch:

1. Coarsely crystalline, white feldspar granite of the Harney's Peak range.
2. Metamorphic schist, (gneiss.)
3. Mica-schist, with segregated quartz-veins containing traces of amorphous graphite.
4. Quartz-schist, having a slaty structure alternating with strata of mica-schist; the whole formation dipping 45° west.

In descending Spring Creek, the first gravel-bars are seen about five miles above Newton's Fork, elevated from 20 to 40 feet above the present level of the stream on flat points and benches of mica or quartz schist.

On making an open cut into these bars on bed-rock, the gravel is found to be almost exclusively composed of quartz, and to yield, on panning, small quantities of gold, from one color to half a cent to the pan. Better results were obtained from drifts run in on bed-rock in the flats near the edge of the stream. The gravel is full of mica and small garnet-crystals, resulting from the disintegration of the schists, and the gold is associated with black sand and bright scales of iron-ore.

To test the deeper channels in the flat, a shaft 5 by 8 feet was sunk with considerable difficulty to bed-rock, which was reached at a depth of 13½ feet, passing through the following deposits:

Black peaty soil	4 feet.
Brown colored, loose, light gravel	2 feet.
Compact white quartz-gravel, containing about half a cent to the pan of coarse scale-gold	2 feet.
Loose quicksands with bowlders, yielding only fine colors of gold	4 feet.
Decomposed bed-rock, with colors of coarse scale-gold	1½ feet.
Bed-rock; lamellar, talcose schist.	

The quicksand was so loose that water flowed in such quantities into the shaft as to keep one man employed constantly bailing to enable the

others to work. The gravel was panned regularly for every 6 inches depth of the shaft, and the pay-dirt and gravel from off the bed-rock tested by washing a number of pans and comparing the results. Scales of mica largely composed the lighter gravels and white quartz, and slightly water-worn garnet-crystals were found in the more clayey layers. The pay-streak was not on bed-rock, but nearly 6 feet above it in the first compact layer of gravel.

Finding a number of prospecting pits in the vicinity, which had been sunk by a party of miners from French Creek, I had the pay-dirt from these holes tested, and obtained results similar to the above. Encountering the miners, they informed me that they had experienced great difficulty in reaching bed-rock on account of water, and that nothing had been found by them up to that time better than the deposits in Custer's Gulch. Spring Creek at this point was 8 feet wide and 6 inches deep, with a moderate current, probably at this time (June 25) affording 250 to 300 miner's inches of water. The placer gravels of this portion of the Spring Creek district may be classed as elevated bars and gulch deposits. The elevated bars are banks of quartz-gravel occupying flat points and rocky benches at the bends of the creek, from 10 to 40 feet above the present channel, and formed by the stream, when, ages ago, it flowed at that level through the valley.

The gulch-deposits cover the bottom-flats of the valleys along every branch where there is flowing water, and are much more extensive in area than the higher bars, and include gravel-deposits resting on bed-rock near the present water-level, old channels of the stream, filled with gravel and soil, winding through the flats, and the more recent placers occupying the present bed of the creek.

The result of prospecting on this branch of Spring Creek seemed to show a general diffusion of gold in nearly paying quantities through quite extensive gravel-deposits, which, in many respects, resemble the bars in Custer's Gulch. The water-supply was, however, considerably greater, and the grade or descent of the valley sufficient to enable the deposits to be worked with much less expenditure of time or labor, so that, were the deposits of equal richness, they would be more valuable here than on French Creek. These head-branches were, however, only partially prospected up to the time I left the district, (August 1,) and Newton's Fork was comparatively untouched, the whole attention of myself and miners being given to practically testing the value of the richer deposits situated some miles below. While I am writing, hundreds of miners are hard at work, prospecting this region, and the valuable deposits, wherever they exist, will soon be found and made to give up the gold they contain and have held uselessly locked up for ages. At this period in the exploration I was camped with a small party of my miners, about a mile below the junction of Spring Creek and Newton's Fork, for several days. We had been prospecting the head-branches of the stream with results which were not as encouraging as the appearance and character of the gravel-deposits would indicate should be obtained.

The mountainous region to the north and east, embracing the valleys of Spring and Rapid Creeks, was unknown and unexplored. The expedition led by General Custer the preceding summer had passed around this rugged area to the west and north, following the valley of the Box Elder, on leaving the Hills, and the miners who were on French Creek had not, as yet, attempted to penetrate it in search of gold.

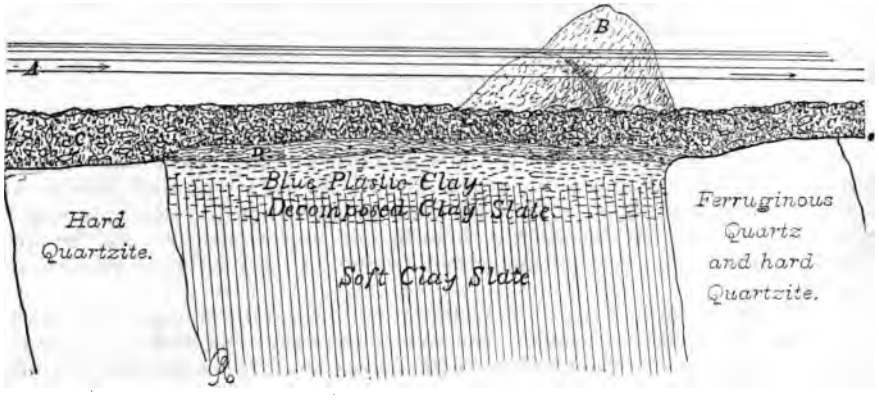
I had noticed to the east the change in the geological formation of the country and regarding the belt of clay slates and quartzites as more favorable to the *production* of valuable placer-deposits of gold than the

metamorphic mica-schists with their superabundance of crystalline quartz, I decided to descend the stream far enough to insure the concentration in the placers of any gold resulting from the denudation of the ledges in the slate-formation, and there prospect and test the richness of the gravel-deposits and prove the value of the district.

Locating in the valley of Spring Creek, about eight miles below Newton's Fork, near where the immense quartz-formation known as the Mammoth ledge crosses the gulch, a few hours' prospecting resulted in the discovery of gold in paying quantities in the placer-deposits of this stream. June 29, 1875, Thomas H. Mallory, one of the best prospectors associated with me the past season, noticed a line of large bowlders extending across the stream, forming a dam or "riffle," and, suspecting that rocks of that size and weight must rest on bed-rock, waded into the creek, and turning over a bowlder, dug from beneath it a blue gravelly clay, a shovelful of which gave on washing six flat scales of gold, about a tenth of an inch in diameter, or five cents to the pan. Putting all my force of miners at work in this place, several of the bowlders were rolled to one side, affording a passage for the stream and decreasing the depth of water above the riffle. On examination the pay-gravel was found to be a deposit about 35 feet in width, crossing the creek and extending into the banks on either side, resulting from the decomposition of a stratum of soft clay-slate in the bed-rock, which had caught and retained the gold swept over it by the stream. The deposit consisted of—

1. Loose gravel of slate and quartz with small bowlders, containing traces of gold, thickness about 6 inches.
2. "Pay-streak," a compact gravel full of small red garnet-crystals, rich in coarse gold, from 3 to 6 inches in depth.
3. Plastic blue clay mixed with rotten slate bed-rock yielding gold in paying quantities, but not as rich as the garnet-gravel; thickness 1 to 2 feet.
4. Lamellar clay-slate, soft and decomposed, forming bed-rock.

The "Mammoth" quartz ledge crossed the bed of the creek just below this rich deposit, and, subsequently it was found that the line of bowlders forming the riffle had lodged in the soft slate above the upper side of the ledge, as shown in the accompanying sketch.



Longitudinal section of the bed of Spring Creek at the point of original discovery.
A. Water of stream.
B. Riffle of large bowlders.
C. Loose gravel and bowlders, poor in gold.
D. Pay-streak heavy red garnet-gravel, auriferous.

A number of pans of the pay-gravel were washed with a result of from one to two grains troy of coarse gold, or 4 to 8 cents to the pan. The average of the whole thickness of clay and gravel was nearly 4 cents to the pan, while the pay-streak would give returns considerably higher if washed separately. A pit was sunk in the bank of the creek, and the pay-streak found equally rich. At a depth of 5 feet from the surface several inches of garnet-gravel overlaid a yellow clay a foot in thickness, resting on rotten slate and quartz bed-rock. The average result on panning the clay and gravel of this pit was about 4 cents to the pan. Subsequently I saw the soldiers of the escort obtain from 10 to 15 cents to the pan from the pay-streak in this pit. After prospecting for several days in the vicinity it became evident that my small force of miners unassisted could not in a season properly examine the gravel-deposits along this section of Spring Creek, and after exploring Rapid Creek I returned to this locality, July 14, with Captain Burt's and Captain Munson's companies of the Ninth Infantry. The fact that gold had been struck in paying quantities caused the first stampede in the hills, and nearly two hundred miners followed me from French Creek, staked out claims, established a mining district, and rendered me subsequently great assistance in prospecting the region.

After a few days' work comparing my results with those obtained by the miners, who had staked claims for several miles along the creek above and below my camp, the following dispatch was, through the kindness of Col. R. I. Dodge, commanding the escort, sent by special courier to Fort Laramie and telegraphed to Washington:

CAMP ON SPRING CREEK, BLACK HILLS OF DAKOTA,
July 17, 1875.

To Hon. E. P. SMITH,
Commissioner of Indian Affairs, Washington, D. C.:

I have discovered gold in paying quantities in gravel-bars on both Spring and Rapid Creeks, from twenty to thirty miles northeast of Harney's Peak.

The deposits are the richest yet found in the hills, and are very favorably situated. There is a good head of water in the streams, amply sufficient for working purposes.

The gold is derived from quartz-ledges of enormous dimensions in a belt of clay-slate and quartzite twenty miles in width, crossing the Hills in a northwesterly direction at this point. The clay from the bed of the stream near camp yields from 4 to 8 cents to the pan, and several pieces of about the value of a dollar have been found by the soldiers. I am engaged in prospecting the value and extent of the region.

* * * * *

WALTER P. JENNEY, E. M.,
Geologist Exploration Black Hills.

In order to test the richness of the gold-deposits in the bed of the creek, it was necessary to turn the water out of its present channel. With the assistance of the soldiers a dam was built across the stream above the point of discovery and the water of the creek conveyed by a ditch 1,000 feet in length across a bend and returned to the channel below the place we wished to test, leaving comparatively free from water about 400 yards of the former bed of the stream. Before reporting definitely on the richness of the new discovery I wished to test on a practical scale the gravel from the different bars, and for this purpose constructed from rough boards, whip-sawed from the native pine, a small box sluice, 10 to 12 inches in width, formed of two boxes 14 feet in length. This work had consumed more than a week. In the mean time the soldiers who were not employed in assisting me had been hard at work in the bed of the creek above the riffle, washing the clay-gravel in pans and rockers, with quite remunerative results. Several ragged and irregular pieces of gold with oxide of iron adhering in the cavities had

been found, weighing from ¾ dwt. to 1½ dwt. and worth from 75 cents to a dollar and a half. From 5 to 15 cents to the pan was usually obtained from the pay-streak, and the soldiers sometimes washed out nearly a dollar's worth of gold in three or four hours' work with a pan. From twenty buckets of dirt taken from the bed of the stream and, washed in a rocker, 2 dwt. of gold or nearly $2 was cleaned up, while the pay-gravel in places yielded as high as 75 cents from five buckets of the top gravel—equal to $11.25 per cubic yard.

Working as they did, often waist-deep in the water of the creek, under many disadvantages from want of skill and tools, letting their tailings fall back into the holes from which they dug the pay-dirt, and, from the pasty and clayey character of the gravel, obtaining but a portion of the gold which it contained, the above results are quite remarkable. For, despite all drawbacks, from an area about twice the size of the floor of a wall-tent, (8 by 18 feet,) not less than one and a half ounces of gold were obtained.

The water leaking through the dam, and that derived from a number of small springs in the bed of the creek, produced a stream of about thirty miner's inches flowing through the channel, from which the creek had been turned, causing great annoyance and difficulty in working, which could only be entirely obviated by constructing a bed-rock drain several hundred feet in length, an undertaking that would consume too much time.

To exclude the water from the strip of pay-gravel crossing the creek at the original discovery while testing it, a wing-dam was built around the deposit, and the pit kept moderately dry by continuous bailing. The sluice was placed in position, the first box into which the gravel was shoveled being left open, and a longitudinal riffle placed in the second to catch the gold. A sufficient head of water was brought in a small conduit from the main ditch, and the gravel, clay, and decomposed bed-rock, covering a space 8 feet by 9 feet, dug out to a depth of 18 inches, and put through the sluice. The result, on cleaning up after four hours' work, was one-third of an ounce troy of coarse scale-gold, worth $6.48. This was obtained from four cubic yards of gravel, from which the soldiers had previously taken the cream of the deposit, and quite a large portion of the material sluiced was tailings that had been once worked. The next day the sluicing was continued at the same place, a fresh portion of the creek-bed being inclosed by a wing-dam. The result of six hours' work was one-half ounce troy of gold, equal to $9.72. The result of the work of both days may be summed up as follows:

4 hours' work produced ⅓ ounce troy gold =	$6.48
6 hours' work produced ½ ounce troy gold =	9.72
10 hours' work produced ⅚ ounce troy gold =	16.20

Five men were employed in these tests, one of whom was constantly at work bailing the water leaking through the wing-dam into the pit, while the others picked up bed-rock, shoveled the gravel into the boxes, and tended sluice. They worked, however, under so many disadvantages, that, with a sluice of proper size and a bed-rock drain, two men could have easily done the same work in the same time, with probably a somewhat increased yield of gold. But even charging this return of $16.20 with the labor of five men for ten hours, the result was $3.24 per day per man, and with economical and skillful working on a larger scale the clean-up should equal at least one-half ounce or $10 to the hand. The

soldiers had been panning previously from this spot for two weeks and worked out the richest of the gravel, and on weighing the gold in their possession I found that they had obtained about $32 from the area I had sluiced in both days' work, which measured 216 square feet and had been excavated 18 to 20 inches in depth. Or 12 cubic yards of gravel put through the sluice had yielded $16.20 in addition to that obtained by the soldiers, giving $48.20 as the total yield, or about $4 per cubic yard. The water leaking into the pit gave a great deal of trouble, preventing the bed-rock from being properly cleaned up, and the blue plastic clay on being shoveled into the sluice, even after puddling, rolled into balls and washed through the boxes unchanged, carrying with it any gold which it contained. On testing the tailings which concentrated under the tail of the sluice, I found that considerable gold had in this way been swept through and lost, the sluice being too short to properly work so clayey a gravel. The soldiers rockered the heaviest of these tailings and the lumps of clay, obtaining about ½ dwt. of scale-gold from them. Large quantities of red garnet-crystals were caught in the riffles, together with cubical crystals of iron-pyrites and round water-worn pieces of hematite iron-ore. No quicksilver was employed, as I wished to procure a sample of the gold in its natural state for assay.

The richest layer in the deposit was the lower part of the red garnet-gravel where it rested on the upper surface of the blue plastic clay. Pieces taken from this contact showed, on breaking, scales and particles of gold contained in it. The bed-rock, as far as we dug into it, about a foot below its surface, contained coarse gold in small quantities, probably caught in crevices in the rock before it decomposed. The soldiers, under the direction of John Roberson, for two days sluiced the gravel from the bed of the creek below the riffle, but found the bed-rock either a hard massive quartzite, worn by water smooth and level, or a ferruginous quartz with masses of crystalline iron-pyrites—the outcrop in the creek of the Mammoth ledge. The gravel was loose and poor in gold, and the character of the bed-rock prevented it from ever retaining any gold swept over its surface by the stream. Only about 25 cents and $1 were obtained by these tests. Afterward they put in a wing-dam just above the area I had sluiced out, and found a few square feet of the clay-gravel, but above that the bed-rock pitched up-stream and changed to a hard quartzite with loose, poor gravel. The result of about six hours' work was $2.70 gold, mostly obtained from the small quantity of clay-gravel adjoining my pit. No one attempted to follow this deposit far into the flats on the banks of the stream, though it gave equally good results at either end, and may have been continuous for some distance across the bottom. In review of this deposit, it may be described as a strip of plastic clay crossing the bed of the creek, and resulting from the decomposition of a strata of soft clay-slate, located on the rise of the bed-rock, while, both above and below, was a hard massive quartzite, smooth and water-worn, but protecting the slate from being rapidly cut away by the current of the stream. The sample of gold obtained by this test was submitted to Mr. Ricketts, assayer at the School of Mines, New York, for the determination of its fineness and value per ounce. The results of two assays, each made in duplicate, are annexed, showing that the gold from this district is very pure, being $946\frac{4}{10}$ fine, or $22\frac{3}{4}$ carats, and, just as it is washed from the placers, is worth $19.44 to $19.63 per ounce.

Certificate of assay.

SCHOOL OF MINES,
New York, January 6, 1876.

SIR: The sample of placer-gold from Spring Creek, Black Hills of Dakota, submitted to me for examination, contains, by assay of raw dust without previous melting—

Gold	937.8 fine.
Silver	45.9 fine
Base metal	16.30
Total	1000.00

The excess of base metal is due to the presence of oxide of iron, adhering to the particles of gold.

The value in gold-coin of one ounce troy of dust is—

Gold	$19.384
Silver	0.057
Total	19.44

Very respectfully,

P. DE P. RICKETTS, *E. M.*

WALTER P. JENNEY, *E. M.*

Certificate of assay.

SCHOOL OF MINES,
New York, January 6, 1876.

SIR: The sample of placer-gold from Spring Creek, Black Hills, submitted to me for examination, contains, by assay of the melted bar made by sampling about one ounce of the raw dust and melting to free it from oxide of iron—

Gold	946.4 fine
Silver	50.4 fine.
Base metal	3.2
Total	1000.00 fine.

The value in gold-coin of one ounce troy of melted dust is—

Gold	$19.562
Silver	0.062
Total	19.624

NOTE.—The value of pure gold per ounce troy is $20.67; the value of pure silver per ounce troy is $1.24.

Very respectfully,

P. DE P. RICKETTS, *E. M.*

WALTER P. JENNEY, E. M.,
Geologist Black Hills Expedition.

About 100 feet above the original discovery an attempt was made to test the creek-bed by building a wing-dam to keep out the water and sinking a prospecting hole inside of it. But after a day of hard work we were obliged to abandon the working at a depth of 4 feet, springs of water bursting through the gravel and flooding the pit. From three to four colors of gold were obtained from the loose gravel.

In a broad gravel-flat a quarter of a mile below this point a prospecting hole was sunk to bed-rock, which was reached at a depth of 6 feet, and found to be hard quartzite covered with loose gravel resting on a surface worn as smooth as a floor by the water. Several pans of dirt were washed from this pit, but not a color of gold was found. Another pit located in an old channel had to be abandoned at the depth of 5 feet, quicksand being struck, so fluid that it flowed into the working and caused the walls of the pit to cave in.

Two prospecting holes in the flat where the Mammoth ledge crossed the gulch struck a cement of quartz pebbles and oxide of iron so hard as to be penetrated with great difficulty. The same cement several feet in thickness could be seen capping the ledge on the hill near the creek, but on panning it failed to give a trace of gold. Near my camp a small sluggish branch entered the creek from the south, and about half a mile above its mouth a prospecting hole was sunk in the flat. After passing through about 6 feet of soil, gravel, and bowlders, a black, peaty muck was encountered and penetrated a depth of 7 feet, when the water, bursting in, flooded the hole, and a pole 5 feet long was easily thrust down through the muck in the bottom of the shaft, but failed to reach any compact layer of gravel.

A similar experience was the result of a hole put down by "California Joe" on his claim below camp. After passing through 6 feet of large bowlders and compact gravel, a deposit of black muck was struck, and finally an old beaver-dam, composed of sticks and mud, was passed through, resting on another layer of muck, at which point the work was stopped by the water. The valley below the Mammoth ledge was contracted in width, and appeared to have been gradually filled up since it had been excavated. Bed-rock was reached in only two places, although a number of shafts were sunk by the miners, and in these cases the rock was hard and the gravel poor in gold.

The hills bordering the stream were composed of thick strata of massive quartzite upturned on edge, and the narrowing of the valley was doubtless due to the hardness of this belt of rocks resisting denudation and the forces which excavated it. Above the original discovery, for nearly five miles, the valley was broad and open, with rolling and broken hills of siliceous and clay slates, with occasional belts of quartzite. Here the gravel-deposits were very broad and extensive; flats, in places a quarter of a mile wide, extended along the banks of the creek, while elevated bars were to be found at the bends of the stream and sides of the valley, which promised to be very valuable. One of the most noted of these older deposits of the stream, discovered the past season, was the celebrated "Stand-off Bar," concerning the ownership of which there promised, at one time, to be a serious difficulty that was only avoided by the determination of its discoverers to "stand-off" all intruders. John W. Allen, the present recorder of the district, in a letter to the Chicago Inter-Ocean, thus describes this deposit, which proved to be so rich that the owners caved in the drift on leaving the Hills, to prevent any stragglers from working the bar during their enforced absence.

CHEYENNE, WYOMING TERRITORY,
August 30, 1875.

To the Editor of the Inter-Ocean:

After prospecting a short time in the park we moved to Spring Creek or Jenney's Gulch, and on the morning of the 20th of July we commenced prospecting Stand-off Bar. We did not work more than half an hour until we panned out 25 cents to the pan; found coarse gold and ran across the bar about 35 feet. From the last pan of dirt taken out of the face of the drift we got one pennyweight and three grains, or what we term a good dollar to the pan. This is about one mile up Jenney's Gulch, above Professor Jenney's discovery. We panned several pans that weighed from 25 cents to 50 cents, and from 78 cents to 93 cents to the pan; it ranged all the way from 10 cents to $1. * * * We prospected also on Castle Creek, and have proven beyond a doubt there are good placer-mines there as well as on Spring Creek. We also found good six-dollar per day diggings on Rapid Creek, and had not the military order arrested our work we would soon have had plenty of the yellow metal out of the ground to have shown the world that the Hills are very rich. While we were preparing sluice-boxes, whip-sawing lumber, &c., preparatory to working our ground, we got the "grand military shake," and had to leave our claims and the Hills. * * *

JOHN W. ALLEN.

Having returned to the Hills after the withdrawal of the military forces, Mr. Allen writes me under date January 2, 1876:

Our bar (Stand-off) pays $1 in gold per hour per man employed; have on hand 26 ounces of bankable gold-dust taken out inside of three weeks.

Mr. James Allen, of Cheyenne, who visited Spring Creek at that time, writes:

I prospected ten pans of dirt from Stand-off Bar and got for my trouble $5.35. I am perfectly delighted with the country. If anything, it is better and more extensive than has been represented. A company, known as the "Montana company," had only been in the gulch three weeks when I got there; during that time they had built two houses, cut a ditch near a quarter of a mile in length, whip-sawed their lumber for sluices and set them running, and had taken out near $1,000 in nice, coarse, bankable dust.

The claims worked by this company are situated below Stand-off Bar, and I understand that the pay-dirt was obtained by a drift run in 50 feet on the rim-rock of an elevated bar, as high as $110 being obtained in one day's work by three men. The companies could not run their sluices more than six hours during the warmer part of the day, owing to cold and frost, yet obtained from six to seven dollars per day per man as the result of this limited work.

Owing to the numbers of small springs in the flats, it is doubtful if they will be worked until covered bed-rock drains can be constructed to remove the surplus water and admit of dry working. The more elevated and easily-worked bars will first be attacked and made to give up the gold which they contain. Near the point of original discovery the soldiers found, opposite their camp on the hill-side, a small deposit of gravel, 2 to 3 feet deep, which proved to be quite rich, yielding from 12 to 19 cents to the pan by actual weight.

Just above where the Mammoth ledge outcropped on the south side of the valley, was a hill of cement-gravel which gave colors on rim-rock, and on sinking a shaft in the center of the hill we passed through a hard cement of quartz pebbles, gravel, and bowlders, but after a week's work failed to get bed-rock at a depth of 22 feet owing to the extreme hardness of the conglomerate which was cemented by oxide of iron, probably deposited by ferruginous springs, the iron of which was derived from the decomposition of pyrites in the ledge. The gravel from this shaft failed to show gold on panning, perhaps owing to the particles of gold being inclosed in the hard lumps of the cement. It promised to be a good deposit to hydraulic, as that process would break up the cement and set the gold free. Two or three miles below this point there were some quite extensive gravel-deposits, where a small branch entered the creek from the north, that were reported to prospect well by the miners who located claims on these bars. But lower down, the stream flowed through a deep, rocky gorge cut in the slates, with gravel-deposits at intervals along its course wherever the gorge was not contracted into a narrow cañon. This portion of the stream, extending from the original discovery to the point where the creek sinks in an impassable cañon in the limestone near the foot-hills, a distance of ten or twelve miles, can scarcely be said to have been prospected at all the past summer. In places, the water flowed over the bare slates, and there are no gravel-deposits; but at the bends and forks of the stream bars of considerable size were seen.

Below where the creek sinks in its bed are bars composed of quartz and slate gravel intermixed with a large proportion of limestone and sandstone bowlders. These deposits undoubtedly contain gold, but I was unable to prospect them, there being not a drop of water in the

vicinity at the time of my visit, (July 3;) but in the spring this stream probably flows out into the plains, and these dry arroyos and placers can then be worked.

The available water-supply furnished by Spring Creek for working purposes varies with the season of the year, being probably greatest in April, May, June, and July, the rainy months, and least in October, November, and December when there is little precipitation of moisture.

In turning Spring Creek from its channel, a ditch 2½ feet wide and 2 feet deep, with a grade of 2 inches in 30 feet, was entirely filled, besides about 30 miner's inches which leaked through the dam; and the available quantity of water at that time, (July 25,) I estimated at not less than 350 miner's inches. During the summer-months Spring Creek will afford from 300 to 800 miner's inches of water for mining purposes, the quantity varying with the season and the yearly rain-fall. I had no instruments to accurately measure the grade of the valley of this stream, but by an aneroid barometer I find that the descent of the main stream from Newton's Fork to where the creek enters the limestone is about 1,400 feet in a distance of nineteen miles, or an average grade of 74 feet to the mile. The descent, however, is less than this for the more open and broad portions of the valley, probably 50 or 60 feet to the mile, and greater in the narrow, rocky cañons. The gold of this district occurs in the placers in coarse, flat scales, thick and heavy, intermixed with very little fine dust, and often shows brown oxide of iron adhering in the cavities of the larger pieces.

The assays made by Mr. Ricketts, of the School of Mines, show that this gold is 22¾ carats, or 946 fine, equal to the average of the best Australian placer-gold, and exceeding that from California. It is found associated with small water-worn red-garnet crystals, nodules of hematite iron-ore, magnetic-iron sand, and crystals of iron pyrites, but no other minerals were detected.

The average proportion of gold in the native gold of California, as derived from assays of several hundred millions of dollars' worth, is eight hundred and eighty thousandths, while the range is mostly between 870 and 890. (Prof. J. C. Booth, of United States mint, in a letter to the author, of May, 1867.) The range of the metal of Australia is mostly between 909 and 960, with an average of 925. (Dana System Mineralogy, fifth edition, 1868.)

The gold appears to be derived from the decomposition of the slates and quartzites, as well as from the denudation of the quartz-ledges traversing these rocks. The source of supply of the gold is immense. The side valleys and gulches are often excavated for miles along the outcrops of the gold-bearing slates, and the quartzites, with their inclosed veins, have acted as feeders to the placers of the main valley. Over a very extensive area these rocks have been enormously eroded and the resulting material swept away. The gold it originally contained has been partly caught and retained in the gulches; the rest, intermixed with gravel and bowlders from the metamorphic rocks, and also from the limestone and recent formations in the foot-hills, being carried far out on the plains and scattered broadcast over their surface, so that very little can be ever recovered. From the results of the prospecting done in this district up to August 1, 1875, when I left the gulch, it would be inferred that the character of the bed-rock strongly influenced the deposition of the gold. Where the bed-rock was a hard, massive quartzite, the water had worn it smooth, and no gold was to be found on its surface, while the gravel above it was loose and poor in the precious metal; but where the bed-rock was soft, easily-decomposing slates, it had caught and retained the gold swept over its surface by the stream,

and the gravel above, compact from the clay produced by its decay, was also rich in gold. In the flats and creek-bed, when a stratum of soft slates is found crossing the gulch below, a high and hard bar with valuable deposits should be sought for.

In discussing the area drained by the headwaters of this stream, the characteristics of the schistose rocks covering that section have been already given. The main valley of the creek is excavated wholly in the rocks of the second division of the Archaean, the slate and quartzite formation extending as a belt fifteen miles in width from the granite on the eastern slope of the Harney's Peak range to the northern part of the hills near Crow Peak. On Spring Creek the general strike of the strata is northwest and southeast, with a dip from northeast 60° to vertical, while locally the rocks are seen dipping west at high angles. The rocks of this formation are altered sediments, consisting of hard, massive gray or brown quartzites, lamellar quartz-slates, and soft clay-slates. By metamorphic action of waters holding silica in solution, or by the preponderance of clay or sand in the original sediments, these rocks imperceptibly merge into each other, and the strata of quartzite often cannot be distinguished from jasper or pure quartz veins, except by position and structure. There is a most remarkable uniformity in the hardness and composition of these rocks, not only for long distances along the outcrops of the same strata, but throughout the whole extent of the geological formation of this belt, rocks from widely different localities most closely resembling each other. The metamorphic action seems to have been the product of the mechanical force producing the folding and upturning of the strata in Archæan time. The quartz-veins are not igneous injections, but chemical precipitations from waters holding silica in solution, partly, at least, derived from the wall-rocks of the veins, and undoubtedly formed during the folding of the strata, at which time the gold must also have been deposited. The lower layers of the Potsdam prove this, as they contain in places bowlders from both the veins and the wall-rock, identical in hardness and appearance with the rocks in the immediate vicinity. This chemical deposition of silica would seem to be similar to the silicification of wood, the solution replacing the original rock, atom by atom, and samples of quartz were seen where the original rock blended so imperceptibly with the white quartz that it is difficult to explain the formation of the quartz in any other way. Quartz occurs in the slates either as interlaminated fissure-veins, coinciding with the stratification and often quite extensively developed, or as short and thin veins following, for a few yards, the jointing planes of the slates. It is in the quartzites, however, that the greatest development of quartz is to be found in this district. Strata of sedimentary rock have, by the action of water containing silica and iron in solution, been transformed into hard quartzite intermixed with ferruginous quartz in all proportions throughout the entire thickness and extent of the bed, until it resembles, on its outcrop, an immense ledge of quartz and vein matter, traversing the slates for long distances across the hills. On examination, however, these peculiar formations are found to be altered sediments. There is no fluccan or casing to the ledges, and in the most favorable positions for the existence of slickensides they are seen to be wanting.

One of the most remarkable was known as the Mammoth ledge, which crossed the valley of Spring Creek near the original discovery of gold. The stream had cut its channel through the formation, leaving a bluff from 20 to 30 feet high on the north side of the valley, exposing a fine *section of the* ledge. Near the base of the bluff the quartz was inter-

mixed with a large proportion of yellow and brown oxides of iron, which had evidently resulted from the decomposition of iron pyrites. Where the ledge outcropped in the bed of the creek, the quartz was found to be full of masses of crystallized pyrites, the water having protected it from oxidation. The ledge was bounded on the west by siliceous clay-slates, containing minute garnet crystals, and having a general northwest and southeast strike, and a dip, indistinctly marked, about northeast 60°. The section commencing at the west was as follows:

1. Quartzite and ferruginous quartz, interlaminated and mixed with iron-ore; width 90 feet.
2. Gray, hard, barren quartzite; 50 feet.
3. Ferruginous quartz, mixed with quartzite, clay-slate, and iron-ore; (limonite;) 200 feet.
4. Hard, gray quartzite, forming the eastern boundary of the formation.

This ledge was a study for a mineralogist. It contained undoubted segregated veins of milky quartz, changing in a short distance into cellular, rotten quartz, mixed with limonite iron-ore. Some of these masses of vein-matter were 10 to 15 feet wide, and continuous for short distances; at other places the quartzite became ferruginous, and merged into brown jasper, or, becoming more pure in its composition, changed to white quartz, as though the silica had replaced, atom by atom, the particles of the original sediment during the metamorphosis of the strata. This view seemed most reasonable in viewing the peculiarities of the banded quartz and black quartzite; each rock, while perfectly distinct, seemed to be the result of the difference in the capacity of the layers of the original sediment to allow the silicated solutions to pass through it.

There were no evidences of the comb structure so often seen in mineral-veins, but everything pointed to segregation as the cause of the formation. This ledge was remarkably persistent and continuous across the country. It was traced for four miles from Spring Creek in a southeast direction, and was reported by the miners to extend north to Rapid Creek, a distance of eight miles, still preserving its great width undiminished. A small gulch emptying into Spring Creek from the south was excavated its whole length in the outcrop of this immense quartz-formation. The gravel-deposits near its head were entirely made up of the disintegrated fragments of the ledge. On the south bank of the creek the quartzite was yellow and brown in color, and resembled impure jasper. On breaking, it showed sometimes visible particles of gold, but samples of the rock submitted to Mr. Ricketts, assayer at the School of Mines, proved to contain but traces of the precious metal. The same result was obtained from iron pyrites from the bed of the creek. The oxides of iron from portions of this ledge were bright-yellow in color, resembling plumbic ochre, but on testing with a blow-pipe, they were found to contain neither lead nor silver, but were merely a variety of limonite. The most promising ferruginous quartz from this ledge was roughly tested at the time of its discovery, by crushing several pounds in an iron mortar and panning carefully, but only a color of gold was obtained, and it is doubtful if these immense quartz-formations are of any value except as having furnished gold to the placer-gravels.

In the bluff formed by this ledge, on the bank of the stream, were several small caves penetrating the rock for 10 or 15 feet, like drifts in a mine, which proved to have been formed by the decomposition and washing away of soft clay-slate inclosed in the quartz. There were not less than three of these quartz-formations crossing the valley of Spring

Creek. One two miles below the Mammoth was characterized by a great development of "ribbon-quartz," thin bands of white quartz, and black quartzite or slate alternating in the ledge, giving it a banded or ribbon appearance. In places the rock became a pure white quartz, and, by its superior hardness resisting denudation, formed the crests of the rocky hills and ridges, and could be traced for a long distance across the country.

The only minerals besides gold found in the Spring Creek district were iron pyrites and the oxides resulting from its decomposition. A miner (Mr. Blake) brought me samples of a rock which he supposed to be black sulphuret of silver. He had found it while wandering about in the Hills, having been lost for some time in this vicinity. On testing with a blow-pipe, it proved to be only clay-slate, and did not contain a trace of metal. It was soft, jet-black in color, with a luster resembling very closely the mineral for which he had mistaken it.

Up to the time I left the gulch (August 1, 1875) no valuable quartz-ledges had been discovered, the attention of every one having been given to prospecting the placers. The gravel-deposits of the Spring Creek district, especially for several miles above and below the point of discovery, are extensive in area and very favorably situated for working. The water-supply is ample, and the fall of the stream sufficiently great to enable water to be carried above the tops of the elevated bars without difficulty, and with little expense, while there is room and grade enough in the flats, in places, admitting of bed-rock flumes being finally put in, and the whole thickness of the gravel-flats, as well as the tailings from the elevated bars, being economically worked. Timber of suitable size and quantity for the construction of sluices, flumes, and trestles, is to be found growing abundantly in the immediate vicinity, as well as for various house-building purposes and fuel. The gold is coarse, heavy, and easily saved in sluices, and contains but little silver or impurities to decrease its value. Thus it may be concisely stated: that the gold-placers of this district, worked by the systems and processes which the experience of twenty-five years has led the miners of the Pacific slope to adopt, will pay a handsome return for the labor required to open the deposits and extract the gold.

WHISKEY CREEK.

A small area of the Spring Creek district remains to be described, comprising the extreme southern end of the belt of clay-slates and quartzites included between Spring Creek and the granite ridges and spurs extending east from Harney's Peak. The surface of this region is rugged and broken, though not as mountainous as the granitic area to the south about the headwaters of Wiwi Creek. The valleys and glades are covered with groves of burr-oak of medium size, the crests of the hills with pine, while the bottoms of the ravines and gulches are thickly overgrown with alder, birch, hazel, and hornbeam. The greater portion of this area of slates is drained by the numerous branches of Whiskey Creek, a small stream with from 30 to 50 miner's inches of water (July 20) flowing east from the Harney's Peak range, about six to eight miles south of Spring Creek, and sinking before it reaches the plains. Near the head of this stream, at the junction of the granite with the slate formation, a huge mass of slates, standing on edge, 30 feet in height, was observed projecting from a crag of feldspar granite. The fragment of slates was only partly inclosed in the granite, so that the *north side of the* lenticular peak was composed of slates, while the south

was wholly granite. It was probably a "horse" in the granite dike. In the southeastern part of this area, near the foot-hills, is quite an expanse of Potsdam sandstone and Carboniferous limestone, but near where the water sinks in Whiskey Creek the limestone belt encircling the hills is not more than a mile in width. With the exception of the presence of granite peaks among the slates, the general character of the rocks is similar to that of the Spring Creek Valley, and fine crystals of *staurotide*, mostly twins in lamellar schist, resembling the specimens of that mineral from Lancaster, Mass., were found near the granite ridges. In the lower part of the valley of Whiskey Creek, small gravel-benches occur along its banks, but gold was not discovered in paying quantities, except below where the water sinks in the bed of the stream among the limestone Red-Bed formations of the foot-hills.

From the fact that the area drained by this stream is almost identical, in the character of the rocks, with that of the Spring Creek district, although less extensive, I consider that there are good reasons to expect that, at least in some localities, gold may be found in paying quantities in the gravel-deposits of Whiskey Creek and its tributaries.

The gold-deposits discovered in the dry ravines and arroyos among the Red Beds, where the dry bed of this stream winds through the low hills at the edge of the plains, will be described in the section on The Deposits of Auriferous Gravel in the Foot-Hills.

SECTION IV.

CASTLE AND RAPID CREEKS.

Rapid Creek is formed by two main branches, Castle Creek and the North Fork, each heading in the limestone divide near Crook's Tower, one of the most elevated portions of the Black Hills. It is the only stream on the eastern slope of the Hills flowing a continuous stream of water during all seasons to the Cheyenne. The other creeks sink among the foot-hills, and during the greater portions of the year are marked by dry channels traversing the plains. Though second in size to Spearfish or Redwater in volume of water, Rapid Creek is the largest stream rising in the Black Hills. From its extreme source in the springs issuing from the limestone at the head of Castle Creek to the point where it empties into the South Fork of the Cheyenne, its length, omitting the minor bends, is not less than one hundred miles. Throughout its course it is characterized by a rapid current, the descent of the valley being about 3,200 feet from the source of Castle Creek to the edge of the plains at the foot-hills, and nearly 800 feet in traversing the open plains a distance of forty-five miles to the Cheyenne. The area drained by Rapid Creek and its tributaries has been divided by the miners into the Castle Creek and the Rapid Creek mining-districts, the North Fork not having been located as a district the past season, although gold was discovered in considerable quantities on that branch.

THE CASTLE CREEK DISTRICT.

Castle Creek near its source in the limestone is a small stream fed by numerous little springs issuing from the sides of the valley, and every few hundred feet the creek is dammed by the beaver, producing marshy ponds and boggy tracts of bottom-land. At the head of the creek groves of tall, slender spruce cover the hill-sides, separated by narrow, open glades of grass-land extending between the low hills, producing

most pleasing views; but farther down the stream the spruce is replaced by pine, and the valley is bordered by cliffs of Carboniferous limestone, whose castellated appearance suggested the name of the stream.

The limestone is almost horizontal in its bedding, and the stream gradually cutting deeper through the strata as it descends finally exposes the Potsdam sandstone at its base, resting unconformably on the upturned edges of schistose rocks. Here the lower layers of the Potsdam are seen to be a coarse yellow or brown conglomerate, closely filled with pebbles of white quartz, in places nearly uniform in size, from one to two inches in diameter, worn smooth and round by the action of water. The schistose rocks are exposed in great variety, dipping first west as we descend the stream, and then east at high angles. The strike is in a general north and south, to northwest and southeast, direction.

The rocks of this section evidently belong to the first division of the Archæan, and can be traced south across the park country to the French Creek district, where they are interlaminated with dikes of felspar granite; but no granite is found in this vicinity. The schists are often very micaceous, although a gray talcose quartz schist having a slate-like structure appears to be the prevailing rock, occurring in broad belts interstratified with mica schist. These rocks, though distinct in bedding, insensibly merge into each other in character, mica schist, from a preponderance of mica, becoming a soft, easily-decomposing rock, often highly garnetiferous, while with a greater proportion of quartz it passes into a fine-grained mica schist, or ultimately to a quartzite with only traces of mica.

Chlorite schist and talcose schist are extensively developed on some of the branches of this stream, and strata frequently are found completely filled with small red-garnet crystals often not more than one-thirty-second of an inch in diameter. Quartz occurs as segregated veins, usually not continuous for any great distance, locally expanding into bunches and irregular masses of quartz following the stratification of the schists, but not crossing the bedding. These irregular deposits of quartz were very abundantly distributed through the rocks; often strings of lenticular masses of quartz followed a line of lamination in the schists, or thin veins could be traced for short distances coinciding with the stratification. They were not, however, true continuous fissure-veins, but irregular segregations formed during the folding and metamorphism of the strata. The quartz is usually milk-white and crystalline, sometimes vitreous, transparent, and stained and coated at its jointing planes and surfaces with oxide of iron, but apparently free from iron pyrites and metallic minerals. These quartz-ledges must, however, contain at least traces of gold, and furnish it to the placer-gravels. Small bright-green crystals of ripidolite in flat scales are inclosed in the mass of the quartz, and green chlorite full of red-garnet crystals incases the veins when traversing the talcose and chloritic schists. Proceeding down the valley the rocks gradually change in character, becoming less micaceous, with a greater development of talcose and quartz schists, in places approaching a clay-slate.

Castle Creek, having made a most remarkable bend of eight miles to the north, the greater portion of the distance through a narrow and deep cañon, resumes its former southeast course in a valley excavated among the quartzites and clay-slates of the second division of the Archaean. An attempt was made to explore this cañon by myself and miners; but owing to the prevalence of fallen timber and tangled thickets of small trees and bushes filling the bottom of the gorge, we were *unable to traverse* it with horses beyond a point about seven miles

below where Custer's trail leaves the creek. The exact line separating the two formations, the schists and the slates, was not seen, but the dip was observed changing from west to east, the quartz-veins becoming less abundant in the rocks and free from mica or chlorite and more continuous and regular in formation. Thin quartz-veins followed the jointing planes of the slates as well as the stratification of the formation. The quartz was locally ferruginous and cellular from the decomposition of pyrites, and had more of a mineral-bearing appearance. It is evident, from the change in character of the rocks, that the line of contact of the mica schists and clay-slates must pass in a general northwesterly direction from Spring Creek, near its union with Newton's Fork, across the hills and the cañon of Castle Creek until it is concealed beneath the limestone ridge between Crook's Tower and Custer's Peak. Castle Creek enters the cañon in its north bend among the mica schists, forming a continuation north of the rocks of the French Creek district, and emerges among clay-slates and quartzites identical with the rocks of the lower valley of Spring Creek, and easily traced across the hills to that district. Near the head of a small branch of Castle Creek, entering it from the south just below the cañon, the clay-slates were observed forming the upper portion of a cliff resting unconformably on the schists at its base. Both formations were, however, upturned on edge at different angles, and it is possible that this apparent unconformability of the two divisions of the Archæan may have been the result of a "fault" formed during the folding of the schists and slates. The point where this unconformability was observed, was almost exactly on the supposed line of contact between the two formations. At short distances to the east and west, the peculiar characteristics of the rocks of the different divisions were unmistakably exposed in the cliffs and outcrops of the strata. From the difference in lithological character in the rocks of the two formations, the resemblance between specimens of the schists and slates from the Black Hills and samples from well-known Laurentian and Huronian of Canada and Lake Superior, as well as the observed superposition of the slates and quartzites on the talcose and mica schists, we have been led to regard the clay-slate formation as of more recent geological age than the mica schists so extensively developed on the head branches of Castle, Spring, and French Creeks. This subject will be found treated more fully in the section on the metamorphic rocks by Mr. Henry Newton. On examining specimens of the Archæan rocks in the possession of Prof. T. S. Hunt, I find that schists from the French Creek district resemble closely the "Mont Alban," or White Mountain series of Professor Hunt, which he regards as older than the Huronian.

I was informed by Mr. A. H. McKay, one of the miners who accompanied the expedition of General Custer, that Ross and himself failed to find gold in prospecting on Castle Creek; but on a small branch in the north part of Elk Horn Prairie they obtained the first "color" of gold from the Black Hills July 28, 1874, and during the six days the expedition remained camped on French Creek they improved the time and got gold enough to prove its occurrence in the placer-gravels of that stream.

Gold was discovered on Castle Creek, above the cañon, June 12, 1875, by the miners assisting me in the work of prospecting. It was found in small gravel-deposits along the creek and in the gulches leading into the stream from the south. About two to three miles below the point where Custer's trail leaves the valley, a bar, covering an area of two acres, gave, on prospecting, nearly a cent to the pan of fine gold. This deposit of gravel was 4 to 5 feet in thickness, composed of quartz

and slate pebbles, resting on bed-rock of mica schists, elevated about 6 feet above the water of the creek, and so favorably situated for working that the gravel could be sluiced with very little expense or trouble. Several pits were sunk in the flats, near the channel of the stream, but failed to reach bed-rock, owing to springs of water which could not be kept down by bailing. Small gravel-benches were found on the sides of the cañon below this bar, which gave four to six colors of gold to the pan, but were of too limited area to be valuable.

Above the cañon on the main creek and its branches are small elevated bars, and quite extensive flats of gravel, which were scarcely prospected at all by the miners who staked claims on this creek on the larger placers below the bend. The gold from this portion of the stream is in small, flat grains, resembling that of French Creek, and probably similarly derived from the quartz-veins in the schists.

In July, while I was engaged with my assistants in testing the value of the placers on Spring Creek, a party of miners discovered gold in paying quantities on Castle Creek, below the north bend, and quite a stampede took place to the new diggings. When, three weeks afterward, I visited the new discovery, I found nearly one hundred and fifty miners camped along the valley, prospecting the claims they had taken. Most of those men were old Montana miners, and, working together in companies, had done a surprising amount of work for so short a time. Nearly every claim had been prospected enough to prove its value, and preparations were being made to enable them to work with sluices on a large scale. In one place a bed-rock drain had been dug nearly a quarter of a mile in length, from 3 to 9 feet deep, to drain a gravel-flat where the pay-dirt gave, by several tests which we made, from five to fifteen cents to the pan of coarse, rusty gold. The gravel was at least 80 per cent. water-worn clay-slate in fragments of small size, intermixed with quartz bowlders and pebbles from the ledges. The pay-dirt not only was found as a compact clayey gravel on bed-rock, but also in several pits and drifts occurred in one or more thin layers of clayey gravel, 2 or 3 feet above it. The bed-rock was soft, shelly clay-slate, easily dug several feet in depth with pick and shovel, and holding gold in its crevices as far below the surface as decomposition had penetrated the substance of the rock.

Very few large bowlders were seen in the gravel-deposits, the pay-dirt, as well as the whole thickness of the bars, being mostly a slate-wash, easily treated in sluices with a low grade and slow current of water, owing to the lightness of the material operated upon. The gravel-deposits are flats along the course of the stream, filling the bottom of the valley, and elevated bars on slate benches, 10 to 30 feet above the creek, often quite extensive at the bends of the stream. Several pits had been sunk to bed-rock in the flats, reaching it at a depth of 12 to 15 feet, and in every case striking on bed-rock pay-dirt yielding from 3 to 10 cents to the pan. The elevated bars showed in places 10 to 12 feet of gravel, and the drifts run in on rim-rock exposed the bed-rock pitching in toward the center of the bar. A number of these high bars were tested by my assistants, with a return from the pay-streak of from 3 to 15 cents to the pan. The gold was coarse, flattened scales and rounded grains, stained a rusty-brown color by a thin coating of oxide of iron, derived from the presence of iron pyrites in the slates.

This portion of Castle Creek, extending from the bend to its junction with the North Fork of Rapid, a distance of about eight miles, is in a very mountainous and broken region. The valley is deep, and in *places* quite narrow, and surrounded by high, steep hills of clay-slates,

occasionally intersected by a stratum of ferruginous quartzite mixed with white quartz, similar to the Mammoth ledge on Spring Creek. It is not necessary to dwell particularly on the wealth of this district, as there is no doubt that the gravel-deposits on this part of Castle Creek will prove remunerative when opened. They are very favorably situated for working. The water-supply is quite large, with a grade of at least 75 feet to the mile. The gravel is easily mined and sluiced, and the gold, coarse and readily saved, even without the use of quicksilver. Castle Creek at this point is a fine rapid stream of water, averaging, in June and July, 10 to 12 feet in width, with a depth of 12 inches, probably yielding 300 to 500 miner's inches of water.

RAPID CREEK.

The North Fork of Rapid, heading in several small branches just west of Custer's Peak, where the limestone of the divide bounds the area of slates, is slightly larger than Castle Creek, and near its union with that stream it winds through a deep and narrow cañon in the slates. Gold was discovered, in paying quantities, on this branch by the miners, but the claims were not prospected enough to determine the value of the placers up to the time I left the Hills. For four miles below the forks, Rapid Creek winds and twists through a deep and contracted cañon, cutting across a belt of very rugged and broken peaks, an extension of the ridge from Harney's Peak northwest to this point. Vertical cliffs of slates rise several hundred feet on either side of the stream, surmounted by high rocky hills, covered with pine, the greater portion of which has been killed by fire, leaving the bare and decaying trunks standing. The bottom of the gorge is choked with a dense mass of tall spruce trees, tangled with bushes and fallen timber, making it necessary at the time we first explored the cañon to wade our horses along the channel of the stream. Afterward the miners cut a trail down the cañon, making the journey on horseback along its rocky bed less difficult. There are a few high bars along the sides of the cañon, covered with dead and fallen spruce trees; but the main gravel-deposits are found in the bottom of the gorge itself.

Below the cañon, the valley of Rapid becomes more open, and large and extensive gravel-flats and high bars are seen on either bank of the stream. In places the valley contracts among steep and rocky hills to a narrow gorge, but does not become a cañon until fifteen miles below the fork, where the stream enters a limestone formation, whence, for a distance of four miles, it is almost impassable for horsemen. Only near the forks has the timber been destroyed by fire, and elsewhere through the valley of this stream the hillsides are covered with pine of good quality, while near the foot-hills small groves of oak and elm grow along the banks of the creek. In the more open portions of the valley broad grass-flats skirt its banks or cover the high gravel-bars situated at the numerous bends of the stream. Among the rocky hills these flats are wanting, and the forest extends nearly to the water's edge.

Rapid Creek flows in a parallel course to Spring at a distance of four to eight miles to the north, and cutting through the same belt of clay-slates and quartzites, the description of the rocks of the Spring Creek district will apply, with some slight modifications, to the rocks of this valley.

The immense belts of quartz and quartzite so marked on Spring Creek are not so prevalent on Rapid, but the soft gray and black clay-slates, with small ferruginous-quartz seams, are here extensively de-

veloped. The clay-slates have a tendency to split, under the action of frost and the atmosphere, into long, slender prisms parallel to the bedding of the rock. In some of the cliffs, benches of these slates have weathered out, and the fragments falling down lie in regular piles like cord-wood along the face of the rocks. These prisms are about 4 feet long, with an irregular rhombic section 3 or 4 inches across. They readily split into smaller prismatic fragments an inch wide and a foot or more in length. The slates contain minute crystals of iron pyrites, and the surfaces of the prisms are stained with oxide of iron resulting from its decomposition. Other strata of slates are lamellar in structure, and split into thin plates like roofing-slate. Both forms make excellent bed-rock to catch and retain gold.

A mile above a small branch entering Rapid Creek from the north, a low hill is composed of trachyte intruded between the slates. This was the only occurrence of igneous rock seen in this geological formation south of Custer's Peak, with the exception of the granite of the Harney's Peak range. On this branch float-quartz was found, which, on breaking, showed small particles of gold, but it could not be traced to the vein from which it had been derived.

Samples of quartz brought in by the miners from the hills between Rapid and Box Elder gave, on crushing, two or three ounces in a mortar, and panning, from four to six fine colors of gold. Gold was discovered in paying quantities in a number of places along this portion of the valley, but the miners who staked claims in this district did not open the placers, and prospected the bars only enough to prove the presence of gold. These deposits of gravel, including both the high bars and narrow flats in the cañon, are known to be valuable, resembling those of the Spring Creek district so closely as to render it unnecessary to again minutely describe them. Geologically, Rapid, Castle, and Spring Creeks belong to one district as they are characterized by the same prevailing rocks and quartz-veins, and the gravel-deposits, being formed by rapid streams, with considerable volumes of water and heavy grades, naturally resemble each other.

Reports from Rapid Creek, December 31, 1875, state that "the cañon is located from head to mouth, and 10 cents to the pan is considered a low average prospect in the pay-streak." The water-supply is ample for working purposes, at least double that of Spring Creek. The current is so rapid that it is difficult to estimate the volume of the stream without making accurate measurement. It varies somewhat with the season, probably between 1,000 and 2,000 miner's inches; being greatest in May, and least in the fall and early winter months.

The descent of the valley, omitting minor bends, is from 70 to 80 feet to the mile, measured in straight lines. In places the grade is fully 90 feet, a most advantageous circumstance in working the placers.

Rapid Creek emerges from the cañon in the limestone, at the edge of the plains, and flows through the most beautiful valley in the Hills. Long flats, covered with a rank growth of bottom-grass, line its banks, which are dotted by groves of oak and elm. The side gorges and ravines cutting through the Red Beds and the variegated sandstone of the top of the Carboniferous, expose cliffs several hundred feet in height, pictured with sandstone of all shades of color from yellow through pink to the darkest red. A trail known to the Indians as the "Race Course," following the Red Valley, and completely encircling the Hills at the edge of the plains, crosses Rapid Creek a mile below the cañon. At this point several large springs of cold water free from even traces of *gypsum* emerge from the Triassic limestone, and pour each from 50 to

100 miner's inches of water into the creek. Three miles farther down, a small branch enters Rapid Creek from the north, formed by a number of fine springs of water issuing from the foot-hills about two miles north of the stream, and affording about 39 miner's inches of water, (August 1, 1875,) which will prove useful in working the gravel-bars in that vicinity.

Rapid Creek, above the springs, is a fine stream of water from 20 to 25 feet wide, and 10 to 15 inches deep, with a very swift current. Probably the volume of the water is not less than 2,000 miner's inches in July, and below the springs 2,500 inches is not too great an estimate for the available water. For at least five miles along the valley below the mouth of the cañon, the stream is bordered by the largest gravel bars and flats discovered in the Hills, reaching out to the low ridges of Jurassic foot-hills, among the level plains, and capping broad benches of limestone and Red Beds at the sides of the valley. The amount of gravel brought down by Rapid Creek and piled up in these deep and extensive deposits is very large; not only low hills below the cañon are covered by high bars at several different elevations, but the broad flats along the stream are made up of a deep deposit of gravel, composed mostly of limestone and sandstone, intermixed with some slate and quartz. Several attempts were made by my assistants to sink prospect holes on these flats along the banks of the creek, but the pits had to be abandoned at depths of from 9 to 12 feet before reaching bed-rock, on account of striking springs of water. The loose gravel from these holes gave one or two colors of gold to the pan, but it was probably quite a distance to bed-rock where we stopped working, as the gravel was open and full of small bowlders. To work these flats, if they are found to contain gold in paying quantities, will require the outlay of considerable labor or capital to drain the bed-rock, but the grade of the valley will admit of long covered bed-rock drains being put in for this purpose.

At the mouth of the cañon the stream flows along the face of the limestone cliffs, and the largest high bars are on benches on the north side of the valley, from 20 to 30 feet above the present level of the creek. Open cuts were driven into these bars on bed-rock, finding nearly 20 feet of gravel, and about a foot of pay-dirt on soft limestone bed-rock, giving an average of three colors of gold, or about half a cent to the pan. Similar results were obtained in prospecting several smaller gravel-points at the bends of the cañon for a mile above these bars, and taking into account the ease with which these gravel-deposits can be ground-sluiced off, with the great volume of water available for the purpose so near at hand, I think that it is possible to work them with a good profit. Where the Indian trail ascends the hill on the south side of the valley are three large elevated bars. The lowest, at an elevation of about 40 feet above the creek, covers about four acres, and appears to be 30 feet in thickness. A drift run in on bed-rock showed a foot of compact cement-gravel full of nodules of hematite iron-ore resting on the soft sandstone of the Red Beds, which gave, on testing, an average of three colors, or about one-third of a cent to the pan.

The bed-rock pitched into the center of the bar, which was composed of bowlders and gravel, at least 50 per cent. being limestone and sandstone, the rest slate, quartzite, and quartz in all the varieties found in the area drained by this stream. Above this bar were two others, at elevations of 100 and 300 feet above the creek, which have been described in the chapter on "The deposits in the foot-hills." A similar deposit covers the foot-hills on the opposite side of the ravine, just east

of the lower bar; but, with this exception, all the elevated bars are on the north side of the valley, which extends into the plains a mile and a half wide, bounded on the south by a bare range of Red Bed hills. On the north, a continuous bar, 30 feet high above the flats, extends from the Indian trail down to the small branch heading in the cluster of springs about three miles below. This bar extended along the valley for three-quarters of a mile, and occupied a triangular area of about two hundred acres, bounded by the small branch entering from the north. On the top it was as level as a floor, and on testing the gravel at its edge we obtained, in a number of places, three to five colors of quite coarse gold, or at least half a cent to a cent to the pan, although at the edges of the deposit the gravel was not over 20 inches thick, resting on soft red sandstone of the Red Beds. For want of time my assistants were unable to thoroughly prospect this extensive bar, but it was the opinion of John W. Allen, who made the discovery, that it would pay well when worked by bringing a good head of water on top and ground-sluicing the gravel and soft bed-rock. Several bars of this character intervened between it and the Hills, which gave equally good results on prospecting. In places the bed-rock was soft, white, decomposed gypsum. Below the branch before mentioned there were no more elevated gravel-bars seen, but along the banks of the creek gravel-flats extended as far at least as the outermost ridge of foot-hills.

I consider that the Rapid Creek district, including Castle Creek, is destined to be one of the most productive in the Black Hills. For forty miles along its course, its banks are bordered by deep and extensive placers, forming the largest gravel-deposits on any stream in the hills.

SECTION V.

BOX ELDER AND ELK CREEKS.

Proceeding north from Rapid Creek, a quite extensive area is passed over which, while geologically a continuation of the clay-slate and quartzite belt, presents in its more level surface a strong contrast to the rocky and broken region to the south. This section is drained by two small streams, Box Elder and Elk Creeks, whose largest branches head almost at the very base of Custer's Peak.

A view from the top of Custer shows a comparatively flat country with low, rolling hills; in places groups of small broken peaks are noticed; but the topography is very different from that of the region about the forks of Rapid and Spring Creeks, where sharp serrated peaks rise, one beyond another, as far as the eye can reach, only exceeded in height and magnitude by Harney itself. It is a desolate looking country. Most of the timber has been destroyed by fire and large areas are covered with dead pines. To the east, at a distance of ten or twelve miles, the limestone is seen crossing the hills in an irregular line in a northwesterly direction, and many of the slate ridges and peaks are near the outcrop of the limestone capped by it and the Potsdam sandstone, the remnants of the great sheet of Palæozoic rocks which once covered this area and has since been removed by erosion.

From the base of Custer's Peak the course of each creek can be traced until it cañons in the limestone, generally flowing through small open valleys or broad grassy swales, which in places, however, are contracted

into a rocky gorge in cutting across the occasional strata of hard quartzites.

The belt of Carboniferous limestone encircling the area of metamorphic rocks is only about four miles in width at the foot-hills near Spring and Rapid Creeks, but to the north it becomes broader and extends a greater distance back from the plains into the hills, its western edge following along the north side of the valley of Box Elder as an irregularly broken cliff or wall. Soon after entering the limestone both Box Elder and Elk Creeks sink in their beds and disappear from five to eight miles from the plains. The water must escape through subterranean channels, as, a short distance below where it sinks among the bowlders, the bare limestone bed-rock is exposed perfectly dry for some distance across the whole width of the bottom of the cañon.

Contrasted with the Spring or Rapid Creek districts, the area of slates is comparatively flat, and the grade or descent of the stream much less, becoming greater in the limestone cañon, where for long distances the Box Elder flows in a swift current over bare bed-rock. Box Elder is not a single or main powerful stream like most of the other creeks in the Hills, but an aggregate of numerous small branches formed by insignificant brooks which do not unite until the stream enters the limestone. Many of these head branches are mere threads of water, or contain water only in occasional deep holes, and are dry during a greater portion of the year, the largest fork being but 6 to 10 feet wide and very shallow. Small ponds and broad marshy flats overgrown with a swamp of willows and low bushes are often encountered on the forks of this stream. They are produced by the beaver in damming back the water in the level valleys, and from the same cause large and deep beds of black peaty muck have been formed by the gradual deposition of vegetable matter in these still pools.

Elk Creek is a stream not quite as large as Box Elder, but resembling it in other respects. For three miles of its course it flows through a narrow and crooked cañon in the slates, then emerges into an open and flat valley, with broad grass-flats skirting its banks, through which it winds for about three miles, and, entering the great limestone formation, sinks in the bed of the cañon and disappears. Where the dry ravine of this stream opens upon the red valley at the edge of the plains, several fine springs of excellent cold water burst out from under the Triassic limestone, and form a considerable stream, flowing, however, but a short distance before it sinks and disappears. On Lower Box Elder and on the divides along the valley of Elk Creek there is considerable pine timber which has escaped the extensive forest-fires. The trees are, however, rarely above medium size, growing very thickly together in dense groves. The rocks of this section are clay-slates and quartzites, similar to those of the Spring Creek district.

The occurrence of a broad belt of specular slates containing a large percentage of hematite iron-ore, which extends along Box Elder just above the point where Custer's trail crosses it the second time, is peculiar to this district. Over quite an extensive tract iron is present in the rocks in quantities sufficient to strongly affect the compass. Thick strata of siliceous slates on being followed are gradually found to become more and more ferruginous, until the rock is finally black and brilliant from the excess of particles of specular iron. Frequently the hematite occurs perfectly pure, interstratified in thin layers with white quartz, forming a peculiar rock, the brilliant black of the bands of iron-ore contrasting strongly with the white stripes of quartz, resembling somewhat the jaspery specular ore of Lake Superior, except that the in-

terstratified quartz is white and not red. These iron-bearing strata were upturned on edge, and often 600 to 800 feet broad, with an unknown extent in the direction of the strike. The hematite was so completely intermixed with the quartz as to seriously injure the commercial value of the ore. The thickest layers of pure specular iron which were seen did not exceed three inches in width; and, except the presence of large quantities of silica, the ore seems to be very pure and free from iron pyrites and phosphates.

Near Custer's Peak an immense ledge of massive milk-white quartz extends north and south across the hills, conformable to the slates. Resisting denudation, it caps the ridges for a long distance like a wall, and large fragments detached from it cover the surface of the hill. Samples of the quartz from this ledge were assayed by Mr. Ricketts, of the School of Mines, but not a trace of gold was found in it. Where the slates are extensively developed the quartz-veins are generally thin and inconspicuous; an occasional large ledge is, however, seen of the above character, but among the belts of quartzites broad strata, transformed into impure quartz, are found, similar to the "Mammoth ledge," on Spring Creek. One of these altered strata contained large masses of limonite iron-ore intermixed with quartz, colored and stained by copper, and resembling closely some specimens of Colorado gold-ores. It was a portion of a quartzite belt dipping 60° to the south, and could be traced east and west for a mile across the low hills until the outcrop was concealed beneath the Potsdam sandstone. Several parallel strata of quartz and quartzite were found within a few hundred yards. That forming the "lode" was from 20 to 40 feet wide, a mixture of massive milk-white quartz and limonite iron-ore, with considerable "gossan" ore, resulting from the decomposition of copper and iron pyrites. Samples were carefully taken from the best appearing ore in the outcrop of this ledge and submitted to Mr. P. De P. Ricketts for assay, who reports that the quartz contains small quantities of gold, but, unless richer than the samples assayed, the deposit is of little value. Where the outcrop of this ledge was covered by the Potsdam sandstone the conglomerate forming the lowest layer of that formation was full of large rounded bowlders partly derived from it. Some of these bowlders were 3 to 4 feet in diameter, and contained all the varieties of rock found in the vicinity, including clay-slate, quartzite, ferruginous and ribbon-quartz, and gossan-ore, exactly as they occurred in the adjacent ledges, proving that very little change had taken place in the slates and the inclosed quartz-veins since the commencement of the Potsdam period. Previous to the deposition of this conglomerate, the slate and quartzite rocks were subjected to a very great erosion, which must have removed a great thickness of the strata, but since the elevation of the Black Hills the Archæan rocks in this district have been but little denuded, the remnants of the Potsdam sandstone capping hills and ridges from 50 to 150 feet above the present surface; and although the formations which covered this area at the close of the Cretaceous period have been swept away over extensive tracts, the erosion has extended but a short distance into the slates. In the Spring and Rapid Creek districts, however, the slates and quartzites have been very greatly denuded and furnished a large amount of material to form the placer-gravels.

On Box Elder the gravel-deposits seem to be largely composed of pebbles and bowlders from the disintegration of the Potsdam conglomerate, and only a small portion is derived from the more recent erosion of the slates. Partly from this cause and the flat character of the region, there are few elevated gravel-bars on this stream of any prac-

tical value. The slate-benches and low hills at the bends and forks of the creek are covered in places with a thin layer of gravel, which, wherever tested, gave never more than a color of gold.

There are a few low bars on the larger branches of Box Elder which may be found to contain gold in workable quantities, but the only gravel-deposits of any size are in the flats along the stream and its numerous branches. Several days were spent in prospecting on this stream by a party of twelve miners who were assisting me at the time, but we failed to find gold in paying quantities in any of the flats or bars which were tested. Prospecting in the cañon in the limestone, the bed-rock was found bare in many places, but not a color of gold was obtained either from the small gravel-deposits or by "crevicing" in the bed-rock, though tests were made in every favorable-looking place for several miles down the cañon. Below where the water sinks a high bar was found at the forks of two cañons nearly 100 feet above the present channel, but no gold could be found in it on panning.

The miners who prospected on Box Elder the past summer before they were removed from the Hills did not find gold in quantities enough to encourage them to stake out claims or form a district.

Elk Creek was explored by the topographical party, but was left untouched by the miners, very few being aware that such a stream existed. Gravel-flats and low bars are reported on this creek between the cañon in the slates and the cañon in the limestone, which promised well as far as could be judged from external appearances. In reviewing this district, which it is but justice to state has been only very little prospected, I may record a small water-supply which fails in many places in the smaller branches after August, a grade hardly greater than that on French Creek, and gravel-deposits which are comparatively of moderate extent and not found to be rich in gold as far as they have been tested.

SECTION VI.

SPEARFISH AND BEAR BUTTE CREEKS.

These streams, emptying into the Redwater and the Belle Fourche, drain the extreme northern section of the main range of the Black Hills; rising near the limestone divide between Crook's Tower and Custer's Peak, a spur of the great western mesa, they cut through a narrow belt of slate, quartzite and igneous rocks before entering the limestone formation encircling the Hills. This belt of slates, contracted between the two walls of Carboniferous limestone, is an extension of the quartzite and clay-slate formation covering so broad an expanse of territory on Spring and Rapid Creeks.

From the headwaters of Elk Creek it extends in a direction a little north of west for twenty miles until terminated by the limestone ridge between Spearfish and Floral Valley. Covering about one hundred and fifty square miles, this area of metamorphic rocks has up to the present time been only partly explored and prospected, owing to the exceedingly rugged and impenetrable character of the region. It may aptly be called a "pathless wilderness;" even game-trails are rarely seen, and the surface of the country is so cut up by numerous narrow and abrupt cañons as to be impassable for wagons, and extremely difficult and fatiguing to traverse, even with pack-mules. The bottoms of the cañons and gorges are choked with a tangled jungle of willow and grape-vines, and often beaver-dams extend from cliff to cliff, producing boggy mud-flats whose depths we tried to explore, but found no bottom in the fluid

black ooze. Only in places can the walls of the cañons and ravines be scaled, while the ridges and divides, steep, and broken into innumerable sharp, serrated peaks, are covered by timber, frequently blown down by the wind and subsequently overgrown with thickets of aspen. The slow progress made through this wilderness soon wears out both horse and rider, and the former, instead of being an assistance, has to be led and pulled along most of the way. To find yourself at a "jumping-off place," the end of some sharp ridge between two streams, to descend hundreds of feet into the bottom of the cañon, to slowly climb the opposite side, at last reaching the top of the divide exhausted and out of breath, only to find that you are on the crest of another similar ridge ending in a few hundred yards; to continue this wearisome march for hours and only travel four or five miles in a straight line; such was one day the experience of the party on Bear Butte Creek.

The more mountainous character of the country and the greater prevalence of limestone in the area drained by Spearfish Creek, make the cañons on that stream the deepest and longest found in any part of the Hills. One of the parties exploring Spearfish entered the main cañon near its source to the north of Crook's Tower, and being unable to extricate themselves and horses, were obliged to force their way through its whole length to where it opens out into Redwater Valley, some thirty miles from its head. Most of the distance they waded their horses down the bed of the stream, which, in a swift current flowed over smooth limestone rock. In places the vertical cliffs of the cañon rose from the water's edge, and nowhere did they find a place where the cliffs could be scaled without abandoning the horses. The party reported that the rocks seen were mostly limestone. A narrow belt of slates for some distance forms the base of the cliffs, the tops being Potsdam sandstone, or the limestone of the Carboniferous. This is also true for those branches of Spearfish rising near Terry's Peak, where the Potsdam covers quite an extensive area, while the narrow cañons are cut through it into the slates.

Near Black Butte, at the mouth of Spearfish Cañon, the limestone forms the west wall of the main gorge, while the eastern branches drain a very mountainous tract consisting mainly of igneous rocks. Spearfish emerges from the cañon with a swift current, equalling, if not exceeding, Rapid Creek in volume of water, and emptying into the Redwater, forms, by the union, a fine river, a branch of the Belle Fourche, known to the Indians as Deepwater.

Just above the mouth of the cañon several small streams enter Spearfish from the southwest, heading in the ridge between Spearfish and Floral Valley. On these branches a party of miners discovered rich placer-deposits the past summer which have since been more fully prospected and developed. Wishing information in regard to the location of the new discovery, I wrote to Mr. T. H. Mallory, one of the original discoverers of the district, and received the following reply:

HILL CITY, *January* 5, 1876.

DEAR SIR: Iron Creek runs into Spearfish above Crow Peak. Bear Creek runs into Spearfish lower down and near the buttes. Sand Creek runs into Redwater. These streams all head nearly together, and they, with their smaller tributaries, make a large mining district. They are richer, too, than anything on this side of the hills. One pan of dirt on the discovery of Bear Creek contained $27. I have a report that another small stream running into Spearfish from the southeast is still better than anything yet found. How much truth there is in it Bottsford and I will know in a few days. I send you a little gold from Sand Creek; it has been retorted and does not look bright.

THOS. H. MALLORY.

W. P. JENNEY.

The rocks of this new district are reported to be granite (trachyte?) near the heads of the creeks, and lower down the gulches the bed-rock is limestone, but equally good gold-deposits are found upon it.

The sample of gold sent is quite different from that from Spring Creek, the particles being much smaller, more ragged, and irregular in shape and but little water-worn. So large a proportion of the gold is fine dust that it is not easily saved without the use of quicksilver in the sluices.

Concerning the Bear Creek discovery, I have received the following communication from Mr. George W. Corey, of Cheyenne:

CHEYENNE, WYO., *December* 20, 1875.

DEAR SIR: I have some fine specimens of Black Hills gold that I will send you. They were taken out of Bear Gulch by Frank George de Oliver, who would not sell them, but let me take them to send to you. He took out with a rocker in eight and a half days $165. One lump which I have weighs one and a half ounces. * * * *

GEO. W. COREY.

WALTER P. JENNEY.

Bear Butte Creek drains the northeastern portion of the Black Hills, taking its name from a solitary igneous peak near which its flows, some eight miles from the main range among the open plains. This stream is formed by two main branches uniting in the Red Valley at the foot-hills; one, the East Fork, rises to the north of Custer's Peak; the other, known as Whitewood, heads near Terry's Peak. None of the branches have flowing water within five miles of the edge of the plain, as they sink even before reaching the limestone formation. The East Fork was only explored by the topographical party; and, for want of time and suitable transportation, my assistants were unable to properly prospect and explore the branches of this stream.

Whitewood, heading on the east side of Terry's Peak, unites with Deadwood, a branch rising on the northwest side, forming a swiftly-running stream flowing nearly three hundred miner's inches of water, but sinking a short distance below the forks, and thence continuing as a dry cañon through the limestone to the plains.

Whitewood and its branches flow through narrow and deep gorges excavated in the slates and igneous rocks, with the Potsdam sandstone capping in many places the tops of the narrow ridges between its numerous branches. The base of the Potsdam is here the usual conglomerate of round water-worn quartz-pebbles and small bowlders. The intrusion of the igneous rocks has penetrated the Potsdam as well as the slates and quartzites, and has often metamorphosed the sandstone so that it is unrecognizable, except that traces of its stratification are retained, and the strata are observed resting at a low angle unconformably on the upturned edges of the slates.

The most common form of this altered Potsdam is a brownish granular rock, full of feldspar crystals irregularly distributed through its mass. Locally, this metamorphosed sandstone is seen as a hard granular rock, breaking with a sharp conchoidal fracture, without any traces of crystalline minerals, and specimens in their colored and burnt appearance resemble fragments of pottery-ware. The slates and quartzites are similar to the rocks of the Spring Creek district, and broad strata of quartzite, intermixed with limonite and white quartz, resemble closely the Mammoth ledge on that stream, except that here small ramifying veins of white quartz not more than half an inch wide intersect the dark-gray quartzite like a network—another evidence that these altered strata are the result of the action of solutions depositing silica permeat-

ing the formation. The strike of the slate and quartzite belt is observed to be east and west, at a point a few miles north of Terry's Peak. This formation over great areas is concealed by the intrusion of large masses of igneous rocks forming the more prominent peaks in the district, as Terry, Custer, Crow, Black Butte, &c.

The intrusions of trachyte in the slates usually form dome-shaped peaks, having penetrated or forced to one side the superincumbent strata of Potsdam and Carboniferous. Though in this region trachyte forms in places quite extensive ridges connecting the peaks and covering large areas, no narrow dikes were anywhere observed traversing the slates, and this occurrence of eruptive rocks in dikes so common elsewhere in the Rocky Mountains, seems to be wanting in the Black Hills.

The time of this eruption of igneous rocks appears to have been coeval with the elevation of the Black Hills at the close of the Cretaceous period; the intrusion of feldspathic porphyry forming Crow Peak has upturned all the different formations from the Potsdam to the Jurassic; the Cretaceous having been removed by erosion is not seen in the vicinity. These igneous rocks are very varied in appearance and character, but may be generally classed either as trachyte or feldspar-porphyry, though merging in all gradations into each other, so that an exact classification is extremely difficult. Greenstone occurs both as an olive-green rock without any traces of crystallized minerals and breaking with a fracture like jasper, and also with small feldspar-crystals scattered through its mass forming a greenstone porphyry. The rock composing Terry's Peak seems to be wholly composed of white feldspar, an aggregation of small crystals of that mineral resembling a fine-grained granite without quartz or mica. Custer's Peak is formed by the intrusion of a peculiar massive gray rock with an exceedingly close and uniform texture resembling a compact gray limestone in appearance more than an igneous rock. Black Butte, a high peak on the east side of Spearfish cañon, near its mouth, is made up of a genuine trachyte.

Near Camp Terry, a few miles north of Custer's Peak, the prevailing rocks are garnetiferous mica-schists, resembling the rocks of the French Creek district. This occurrence of an area of schists in the clay-slate formation is not easily explained. Possibly the irregular line of contact between the two divisions of the Archæan may here extend a greater distance to the east. Among these mica-schists on the head branches of the East Fork of Bear Butte Creek the soldiers found gold in the gravel-deposits of the side gulches of the stream, and a piece weighing about half a pennyweight was obtained from one of their prospecting pits near Camp Terry. Gravel-deposits of considerable extent are reported in the valleys of the branches of the East Fork, but have not as yet been prospected by the miners. The area drained by this fork is more open and less rugged than the territory to the west, resembling the Elk Creek district, which it adjoins. Gold has been discovered by the miners on Deadwood and Whitewood Creeks and the numerous gulches running into them in the vicinity of Terry's Peak. The placers are quite extensive and in most places the bed-rock is reported to be near the surface, and the gold is doubtless derived from the disintegration and erosion of the igneous rocks as well as from slates and quartzites.

Having detected gold in similar trachytes in the Bear Lodge range, I consider its occurrence in rocks of igneous origin in this district as extremely probable. The following letter from Mr. T. H. Mallory, formerly one of my assistants in prospecting the gold-field, gives the result

of his explorations on the branches of Bear Butte Creek, since the return of the expedition:

HILL CITY, DAK., *January* 31, 1876.

DEAR SIR: Botsford and I have just returned from a trip to the north. We made locations on Whitewood, a large stream that rises around the northeast side of Terry's Peak and runs down to the Belle Fourche. Starting from the point where the creek runs into the low lands not of the cañon, forming bars, up it to the West Fork, or Deadwood, as it is called, there is no better paying mines for a poor man in the Hills. The ground prospects in the creek and on the bars, all the way down to bed-rock, an average of about two cents to the pan, in fine gold. It is said to be the same on Deadwood. The length or extent of locations on these creeks begins at the mouth of Whitewood, and then running thence up Deadwood, makes a distance of twenty-five miles, all good mining-ground.

A small gulch running into Deadwood, called Black Tail, is said to be good. These mines will certainly pay from $10 to an ounce a day to the man when worked in the spring. They are easily opened, for the bed-rock is not deep like it is on Spring, Castle, and Rapid Creeks.

T. H. MALLORY.

W. P. JENNEY.

SECTION VII.

THE BEAR LODGE COUNTRY.

Forming the extreme northwestern part of the Black Hills, and separated from the main range by the broad, open valley of the Redwater, the Bear Lodge country has a geological system and topography which, while a miniature counterpart of that characterizing the main range of the Black Hills, is a distinct uplift, produced by the intrusion of the igneous rocks forming Warren's Peaks. Covering an area of nearly one thousand square miles, mostly included between the Redwater and the Belle Fourche, this region takes its name from a singularly-shaped trachyte butte "*Mato Tipi*," or "The Bear's Lodge." Surmounting a hill near the north bank of the latter stream, this butte forms the most conspicuous landmark in the region, resembling the base of a ruined and crumbling column, with its shaft nearly 500 feet in height, and the top 1,127 feet above the water in the Belle Fourche.

Warren's Peaks, a cluster of high rolling hills, grass-covered, and nearly destitute of timber, are the most elevated points in the Bear Lodge range, almost equaling Harney's Peak in height, their tops being from 6,700 to 6,800 feet above the level of the sea.

Occupying an area about four miles in diameter, these peaks are composed of coarsely-crystallized feldspar trachyte, apparently destitute of quartz, but sometimes containing hornblende and mica, and often having in the arrangement of the crystals of feldspar, in a granular matrix, a structure like porphyry. This rock, which is seen of different shades of gray, yellow, and reddish brown, seems to be quite readily decomposed by atmospheric agencies, and crumbling away, has given rounded surfaces and outlines to the hills and ridges. Standing on any of the higher of Warren's Peaks the view shows at once the distinct character of the uplift, and the peculiarities produced by it in the topography of the region.

The central peaks are surrounded by others of less elevation, between which ravines radiate in every direction, like the spokes of a wheel from the hub, and give rise to small streams, flowing outwardly from the center, draining the area. Those to the southeast and south, empty into the Redwater; the rest flow into the Belle Fourche or its branches.

To the north an extensive tract is observed wooded with pine of medium size. Scattered groves occur elsewhere on the ridges and in the

ravines, but large areas are comparatively destitute of timber, and broad grass-covered divides are seen to the west and northwest between the streams emptying into the Belle Fourche.

To the east, across the broad valley of the Redwater, excavated in the gypsum and sandy clays of the Red Beds, Crow Peak is seen, an angular blue-black butte, forming the most northern peak in the main range of the Black Hills. Between it and Inyan-kara stretches the great limestone formation so extensively developed on Floral Valley and the head branches of the Redwater.

To the west, (magnetic,) some twenty miles away, Bear Lodge Butte and the Little Missouri Buttes appear in line. From this distance the former resembles in appearance the huge stump of a tree, its surface curiously striated vertically from top to base, and, being perched on the crest of a high, flat-topped ridge, it becomes a very prominent landmark, which, once seen, is so singular and unique that it can never be forgotten. Although the Bear Lodge country is an elevated region, and the different streams have a considerable fall before reaching the Belle Fourche, yet the topography is quite peculiar in the prevalence of long, flat-topped ridges or mesas between the narrow and deep valleys and cañons of the creeks. This is due to the resistance to erosion offered by hard and continuous strata of sandstone of the Jurassic and Cretaceous formations which are here almost horizontal in their bedding, with a gentle slope away from Warren's Peaks.

In a series of annular belts the different geological formations outcrop around the central nucleus of Warren's Peaks. In passing down any of the numerous radiating ravines of the streams for three or four miles, all the several members of the section are successfully encountered in the order of their deposition, from the Potsdam to the Dakota sandstone of the Cretaceous. Upturned at an angle of about 20° by the intrusion of the trachyte, the Potsdam sandstone rests against the slopes of the outer circle of hills. Its lower layers are so metamorphosed by the heat and chemical solutions accompanying the upheaval, that they merge imperceptibly into the igneous rock, until strata which are probably altered sandstone cannot be distinguished from coarsely-crystalline trachyte. Near the base of the Potsdam formation, between strata of unmistakable sandstone, a mass of feldspar trachyte was observed, which had in the eruption escaped between the layers and slightly altered the adjacent surfaces of the inclosing rock. But more frequently the metamorphism seems to have been the result of the action of heated solutions forced between the layers of the sandstone, altering the surface of the fracture and transforming the sedimentary rock into a feldspar porphyry.

Layers of the soft brown sandstone extending horizontally for some distance had been altered in this manner, the rock being shot full of gray feldspar crystals, from one-fourth to one-half an inch long, irregularly distributed through it.

On the west slope of Warren's Peaks a layer of blue slate occurred, inclosed in the trachyte, but conformable in its bedding to well-marked Potsdam about 50 feet above it, and was probably formed by the action of heat on a layer of clay-slate in the base of the Potsdam. Here this formation is full of fine specimens of the large fucoids so characteristic of the Potsdam sandstone in the Black Hills, and great masses of the upper layers of the rocks are perforated by the borings of marine worms. These fossils are found unaltered within a few feet of the trachyte, and would seem to show that the heat accompanying the upheaval of the range and the intrusion of the igneous rocks was not very intense. At

the south of the peaks the whole thickness of the Potsdam sandstone has been so metamorphosed that it cannot be recognized, except by the evidences of an indistinct stratified structure, and its position under the Carboniferous limestone. The altered sandstone on that side is a quartzite more or less porphyritic, with feldspar crystals merging in all gradations into a crystalline rock resembling trachyte. Even here the metamorphism seems to be more from the action of heated chemical solutions permeating the rock than from the direct action of heat, producing a semi-fusion of the Potsdam strata. The Carboniferous limestone succeeds the Potsdam, apparently conformable to it, and forms an encircling range of low, white hills around Warren's Peaks, at a distance of two or three miles. The whole thickness of this formation is at least 600 feet, including the overlying massive sandstones.

The limestone shows but little evidence of metamorphic action, though in places the trachyte has broken through this formation and appears at the surface, altering slightly the upper sandstone. Beyond the belt of Carboniferous, which is nearly two miles wide, the Triassic limestone and the Red Beds occupy a narrow ring succeeded by an expanse of sandstone and clays of Jurassic age, extending for miles across the country. The tops of the ridges are formed by a ferruginous massive sandstone, probably the Dakota sandstone, and where it has been removed by erosion the harder layers of the Jurassic cap the hills and the mesa divides between the stream.

In the interior area of Warren's Peaks no Archaean strata were found, and the slates, quartzites, and schists so largely developed in the main range of the Black Hills were here entirely wanting. The rocks of this district seem to be singularly free from quartz in any form. About five miles southeast of Warren's Peaks, near the head of a branch of the Redwater, a fault in the strata exposes a fine section of the Potsdam sandstone, with its lower layers full of slate and quartzite pebbles, but unfortunately the base of the formation was covered by a talus, and the rock on which it rested could not be seen. On the north side of the area of igneous rocks a trachyte composed of feldspar and black mica was observed, and near by several large loose bowlders of white quartz were embedded in the surface of the ground, but the ledge from which they were derived was not found. Black hornblende also appeared as a constituent mineral, associated with feldspar, in the rocks of this district.

Half a mile northeast of the central peaks a gold-bearing ledge was discovered and traced in a northwest and southeast direction for several hundred yards. On examination it was found to be irregular in shape, without any well-defined walls or boundaries, and merging on all sides into the adjacent trachyte rocks. The rocks composing this peculiar formation were exceedingly varied in character and appearance, and a score of different specimens were collected in a radius of as many yards. The prevailing rock was a very coarsely-crystalline, feldspar porphyry, with a fine porcelain-like matrix, breaking with a sharp conchoidal fracture. The feldspar crystals were often very perfect, and from an inch to two inches long. Flat and thin crystals were common, often joined together, with the shorter axis of one reversed, as "twins." The specimens varied in color from light yellow or yellow-brown to gray, and large masses of rock in the middle of the "ledge" were made up of feldspar intermixed with irregular masses of limonite iron-ore and black oxide of manganese. Bowlders of iron and manganese which would weigh several hundred pounds were scattered over the surface of the ground. The mineral was solid, compact, and exceedingly heavy, but the two oxides were distinct in the mass, though often closely inter-

mixed. Manganese and limonite occurred, filling the spaces between the large feldspar crystals and impregnating the rocks irregularly throughout, until it resembled a "breccia." Evidences of an octohedral or cubical crystallization in the limonite indicated that it was derived from the decomposition of iron pyrites, and traces of the latter mineral were found on breaking the rock.

No gold could be detected in this formation by the eye; but, suspecting its presence, the different specimens collected were carefully sampled and submitted to Mr. P. de P. Ricketts for assay. The result showed the presence of a decided trace of gold, probably contained in the iron and manganese oxides.

Prospecting in the dry ravine, a short distance below this ledge, the gravel from off bed-rock was found to be largely composed of material derived from the disintegration of the ledge. Twelve fine colors of gold, or about half a cent to the pan, was obtained as an average of several tests, and each time nearly a pint of gravel and pebbles of manganese and limonite was left in the pan after washing out the lighter clay and feldspar. It would seem probable that the whole of the gold contained in the gravel in this ravine had been derived from the decomposition and denudation of the above ledge.

The occurrence of gold in trachyte without any quartz being associated with it has been previously reported from several mining-districts in the West, but this is the first instance that has come under my personal observation.

Descending the ravine about half a mile, traces of previous explorers were found. Several prospecting-holes had been sunk near the stream, and considerable work done in the vicinity, probably by a small party of miners early in the preceding spring, as small aspen trees which they had cut down in clearing the ground for working showed half-grown leaves dead and shriveled, but still clinging to the twigs. A number of these old prospecting-pits were baled out, the gravel obtained from off bed-rock, and tested by panning. But in no case did we find gold in paying quantities, half a cent to the pan being the highest result of the trials. It is probable that the miners who dug these holes obtained discouraging prospects, or they would not have abandoned the district without making it known.

Exploring a number of small streams rising near Warren's Peaks, flowing to the north and east, gold was found in gravel-deposits in the flats along the banks of the creeks, in several places, but nowhere in paying quantities, though from want of time we were unable to thoroughly test all the different ravines in this district. The cluster of hills of igneous rocks which have yielded the gold are but four to five miles across. The gravel-deposits formed by the creeks extend, however, for some distance down the valleys, beyond the outcrop of the Potsdam, and are found resting on limestone bed-rock, so that the district is really elliptical in area and six to eight miles in diameter, covering an area of from forty to fifty square miles. The streams being small and the wash not very great, there were no high gravel-deposits, though one or two bars covering about an acre were observed occupying flats elevated three or four feet above the creek. The gravel was 2 to 5 feet deep, composed wholly of feldspar and the soft plastic clay resulting from its decomposition, intermixed with considerable iron and manganese pebbles derived from the ledges. The valleys of the creeks are not deep, but are narrow, contracted, and overgrown with thickets of willow, so that only at intervals are gravel flats of any considerable size found along their course. The most extensive of these bars were found near the outcrop

of the limestone, the bed-rock being soft calcareous sandstone of the Carboniferous age. These deposits were situated so that they could be readily worked, but only yielded, on testing, from one-eighth to one-half a cent to the pan in very fine dust gold.

The gold is derived from the igneous rocks forming Warren's Peaks, most of it apparently from the manganese and limonite ledge on the northeast slope, as the largest quantities were found in the ravines heading near that point. The intrusion of the trachyte forming the peaks having disturbed the Cretaceous sandstone and the underlying beds, it is probable that the Bear Lodge range was coeval with that of the main range of the Black Hills at the close of the Cretaceous period, and that the gold in the trachyte was simultaneously deposited. In reviewing this small district, which is very interesting scientifically, even if the deposits of gold should not be found of workable richness, it may be stated that the bars are of limited area, and usually shallow deposits of feldspar gravel. The gold is fine, and up to the present time has not been found in remunerative quantities. The water-supply is small, but probably sufficient for working purposes during the spring months. The district is remarkable in the occurrence of gold without any quartz whatever being associated with it, and in the fact that the gold is derived from feldspar trachyte-porphyry of so recent a geological age.

SECTION VIII.

THE DEPOSITS OF AURIFEROUS GRAVEL AMONG THE FOOT-HILLS.

A belt of gravel-deposits, resting usually on the Red Beds near the edge of the plains, extends from Red Cañon Creek, in the extreme southern end of the Black Hills, all along the southeastern foot-hills, across the valleys of Minnekata, Amphibious, French, Wiwi, Whiskey, Spring and Rapid Creeks to Box Elder, where the deposits thin out and disappear. On examination, these gravel-beds seem to be river deposits, though in places they cap hills 300 feet above the present bed of the nearest stream. Where the divides between the creeks are quite wide, at the edge of the plains, the gravel is seen to be thickest and most extensively deposited near the valleys of the streams, and to thin out toward the crests of the divides. The gravel appears to have been deposited by the water at the point where the power of the stream became insufficient to transport farther in large quantities bowlders of this size and weight, and the beds resemble somewhat shore or estuary deposits, such as are formed near the mouth of a stream emptying into a lake or sea. These gravel-banks have been formed since the elevation of the Black Hills, and the great Tertiary sea which gave rise to the extensive beds of that age in the valleys of White River and the South Cheyenne may have reached to the foot-hills of this range. A gravel "wash" from the Black Hills is found all over the surface of the plains to the north, east, and south of the range. Near the Cheyenne this gravel forms a conglomerate 6 feet in thickness between the top of Cretaceous No. 5 and the base of the White River Tertiary, and also occurs as scattered gravel and bowlders on the tops of the Tertiary hills, showing that it has been deposited since the close of the Cretaceous period, both before and after the Later Tertiary. These gravel-beds are made up of a mixture of bowlders and pebbles from all the harder rocks found in the different geological formations on the eastern slope of the Black Hills, including granite, trachyte, schist, slate, quartzite, and quartz in all its varieties, mixed with a variable proportion of sandstone and limestone from the disintegration of the Potsdam, Carboniferous, and Red Beds.

The preponderance of any particular rocks in the gravel seems to be the result of the position of the deposits and the circumstances influencing the erosion which produced it. The more elevated beds contain a less proportion of limestone and sandstone bowlders, mingled with those from the Archaean rocks, than the deposits at lower levels, formed after deep gorges had been cut by the streams through the recent formations. A layer of gravel a few inches in thickness covered the lower foot-hills near Box Elder, but the deposits were thin and spread out over a considerable area. It was impossible to prospect them for gold, as there was not a drop of water in the bed of the stream for several miles up the cañon. This peculiar formation of high gravel-capped hills does not become extensively developed north at the valley of Rapid Creek, although a thin wash of limestone and sandstone bowlders, mingled with a little quartz and slate, covers the foot-hills as far to the north and west as the forks of Spearfish and Redwater.

Where Rapid Creek bursts through the foot-hills and flows out on the plains are very extensive gravel-beds of this character, evidently deposited by the stream at different periods as they cover the tops of hills at three distinct elevations, respectively at about 50 feet, 100 feet, and 300 to 350 feet above the present bed of the creek. The lowest of these deposits occupies benches and flat-topped hills formed of the soft red standstone of the Red Beds. The gravel was mostly composed of limestone and sandstone bowlders, mingled with quartz, slate, and ferruginous quartzite. The next, also resting on the Red Beds, was of similar character; not more than 50 per cent. of the gravel was derived from the metamorphic rocks. Both of these deposits were on the side-hills of the valley, in places forming banks or terraces 20 to 30 feet in height, and should properly be classed as high bars. The gravel from off bed-rock, obtained by drifting into the face of these bars a distance of 4 or 5 feet, gave one to two colors of gold to the pan. The highest gravel-deposits were in places 30 to 40 feet in thickness, capping the tops of the hills of Carboniferous and Triassic limestone, often at a considerable distance from the present valley of the stream; the lower layers contained waterworn bowlders, 1 to 2 feet in diameter, of quartz, slate, quartzite, granite, and trachyte, both feldspathic and hornblendic, but scarcely a trace of limestone or sandstone rocks are found in these more elevated deposits. Wherever tested, the gravel from off bed-rock gave small quantities of gold on panning.

On Spring Creek, below the limestone cañon, prospecting was out of the question for want of water, though it is probable that in the early spring months this stream flows out into the plains.

In the dry side ravines of Whiskey Creek, among the Red Beds, gold was discovered by a party of miners entering the Hills. Prospecting up a dry gulch, they obtained 25 colors of gold from the dirt shaken from the roots of a small bush growing in a narrow crevice in the bare sandstone bed-rock at the bottom of the ravine. This locality, known as the "rosebush diggings," derived its gold from the gradual washing down into the ravines of the gravel-deposits capping the hills, by the action of occasional heavy rains, when for a short time a stream of water would flow through the gulch and sluice the gravel accumulated in it, the gold being caught in the crevices of the bed-rock, while the dirt was swept away. Prospecting in one of these side gulches, about half a mile from the main stream, the dirt from the crevices in the bed-rock was found to yield from 5 to 15 cents to the pan. The gold was in fine particles, associated with small red garnet crystals, derived from the schists *in the neighborhood* of Harney's Peak. This ravine was excavated

about 200 feet in depth, through the Red Beds. Its bottom was formed of a pavement of the upper layers of the Carboniferous sandstone, while the hills on both sides were covered with a deposit of slate and quartz gravel which had furnished the gold.

A mile below, the small side gulches in the Red Beds afforded in places 5 to 10 cents to the pan of gold, but the supply of water at this time (July 20) was so small that the miners decided to give up prospecting in the vicinity and abandon the diggings until the spring rains should fill the water-holes and make it possible to work the pay-dirt in rockers, if any deposits rich enough for that purpose should be discovered.

About five miles south of Whiskey Creek, at the edge of the plains, a conglomerate 30 feet in thickness caps hills 100 to 150 feet in height, of the soft sandstone of the Red Beds. The conglomerate is composed of granite, quartz and slate bowlders, cemented by sand and lime into a loosely-cohering "cement," the lower layers of which contain quartz bowlders, 1 to 2 feet in diameter. The small gulches in the vicinity are full of the quartz gravel, resulting from the decomposition of the conglomerate, and undoubtedly contain gold, but unfortunately there was not a drop of water anywhere to be found in the neighborhood, and I was obliged to relinquish the attempt to prospect them. Similar gravel deposits encircle the foot-hills crossing the valleys of French, Amphibious, and Minnekata Creeks, and in this connection it would seem not inappropriate to give a tradition relating to the gold-deposits in this portion of the Hills.

Toussaint Kensler, a half-breed Indian, who had worked in the gold mines of Alder Gulch, Montana, was confined in prison under sentence of death for murder. Escaping, he was not heard from for a long time; when he appeared at the agencies, having in his possession several goose-quills filled with gold-dust, and a fossil skull which he had found in the Bad Lands on his way from the diggings he reported he had discovered. Being re-arrested, he was taken back to prison, and hung for the crime for which he was originally sentenced; but before the execution he drew a map of the locality where he claimed to have discovered gold, and the routes traveled in going to and from the agencies, with the distances and names of the principal streams marked unmistakably in the sketch. He stated that he followed down Hat Creek to the South Fork of the Cheyenne, crossed that stream, and on the second creek of any size entering the Cheyenne from the north below the mouth of the Hat Creek, he discovered gold about ten miles from the Cheyenne, among low hills, but outside the main range of the Black Hills. He described the locality as among hills capped with high and thick gravel bars of large size. Here he found rich gravel, and in a short time obtained his sample of gold by washing the pay-dirt in a small tin dish. A tracing of the map drawn by Kensler is before me while I am writing. On comparing it with the map drawn by Dr. M'Gillycuddy, topographer of the expedition, I find that it agrees very closely with the latter, in regard to distances, directions, and the bends of the Cheyenne, and that the stream on which Kensler discovered gold was either Amphibious Creek or French Creek, probably the former. Quite extensive gravel-deposits are known to occur in the vicinity, and it is probable that Kensler was the first discoverer of gold in the Black Hills, obtaining his pay-dirt from the small ravines and gulches among these gravel-beds, where the gold had been concentrated by heavy rains. Should these elevated gravel-deposits on further exploration be found to contain throughout their thickness sufficient gold to warrant

working by the hydraulic process, water can be conveyed from the streams in the Hills to them in many places under a considerable head, as they are elevated only about 3,800 feet above the sea, while the streams 15 miles into the interior are flowing through valleys at an elevation of 5,000 feet. On Rapid Creek, a large volume of water, at least 2,000 miner's inches, under a head of 75 feet to the mile, can be made available for working these high bars above the valley, at a moderate expenditure of capital and labor required to construct the flumes. Only two streams, Rapid and Minnekata, having gravel-deposits of this character in their valleys, form a continuous stream of water to the Cheyenne; the rest all sink in their beds among the foot-hills, several miles from the plains. Among some of these dry ravines, cutting through the gravel-deposits, miners in the future may make good wages washing the earth from the bottoms of the gulches in rockers, during the early spring months, when there is sufficient supply of water in the vicinity.

SECTION IX.

CONCLUSION.

Very few minerals were found during the exploration, and until the quartz-ledges have been more thoroughly prospected and opened it is premature to discuss the occurrence or non-occurrence of any of the valuable minerals or ores in the Black Hills.

A number of samples of quartz were taken from ledges in different parts of the gold-field, and submitted to Mr. P. De P. Ricketts for assay, but were found to contain only traces of gold. The following is Mr. Ricketts's report in detail:

SCHOOL OF MINES, COLUMBIA COLLEGE,
New York, January 24, 1876.

Certificate of assay.

SIR: The samples of ores from the Black Hills, marked as below, submitted to me for examination, contain no silver, but gold as follows:

	Gold.
No. 1. Jasper, from Jasper Hill, Box Elder	None.
No. 2. Porphyry ledge, Warren's Peaks	Trace.
No. 3. Empress lode, Box Elder	Heavy trace.
No. 4. Great Quartz ledge, Box Elder	None.
No. 5. Lee Anna lode, Spring Creek	Trace.
No. 6. Sullivan's lode, Castle Creek	Heavy trace.
No. 7. Lode on Rapid Creek	Trace.
No. 8. Iron-pyrites from Spring Creek	Trace.
No. 9. Lode on Rapid Creek—quartz	Heavy trace.
No. 10. Lode on Rapid Creek—quartz	Heavy trace.
No. 11. Empress lode, Box Elder—quartz	None.
No. 12. Lode on Rapid Creek	Trace.

The amount of gold found in each case was too small to weigh, although the charges of ore were large.

Very respectfully,

P. DE P. RICKETTS, E. M.

WALTER P. JENNY, E. M.,
Geologist Black Hills Expedition.

Hematite iron-ore exists in extensive deposits in the slates on Box Elder, but is so intermixed with quartz as to greatly deteriorate its value.

"Blue block" iron-ore (siderite) weathering to limonite was found of *good quality in the* black clay shales of the Cretaceous on Beaver Creek.

The deposit covered quite a large area, and consisted of three horizontal layers respectively 8 inches, 3 inches, and 5 inches thick, separated by a few feet of clay shales. This ore closely resembles the block ores of the coal-measures of Kentucky and Pennsylvania, which are worked in the small charcoal iron-furnaces scattered through the timbered districts.

Gypsum is found in beds from 5 to 12 feet in thickness interstratified with the red clays of the Red Beds. Usually, there are three or four of these layers of massive white or gray gypsum in the formation, but in places they seem to be wanting and to be replaced by sandy clays.

These Red Beds entirely surround the Black Hills, but are so exposed by uplift on the southern and eastern sides as to conceal partially the gypsum beneath the *débris* of the clays.

In Redwater Valley, in the northwestern portion of the Hills, and in the vicinity of Inyan-Kara and Sun Dance Hills, the gypsum beds are very prominent, and the mineral occurs in extensive strata, so exposed as to be easily mined should there ever be a demand for it.

The Carboniferous limestone which covers a large area of the Black Hills is very pure, and when burnt will make an excellent white lime suitable for building purposes. Building-stone is everywhere abundant in the Hills, and of good quality, including granite, slate, quartzite, sandstone of all shades of color and degrees of hardness, limestone both white and gray, and many varieties of trachyte and altered sedimentary rocks.

Some of the soft variegated sandstone of the Red Beds is very ornamental, embracing every shade of color from yellow, through orange and pink, to the darkest red.

Springs, issuing from the black clay shales of the Cretaceous on Beaver Creek, were found to be strongly acid, and astringent to the taste, turning blue litmus red, and probably containing alum and free sulphuric acid. Similar springs were reported to be found near Buffalo Gate, on the southeastern side of the Hills. A yellow efflorescence resembling flowers of sulphur in appearance is often seen on the surface of these clay shales. On testing, it was found to be a basic sesquisulphate of iron, probably identical with a yellow salt of similar composition used in medicine.

In reviewing the gold-deposits in the Black Hills, there are some peculiarities in the occurrence which require to be specially noticed.

The gold contained in the trachytes of the northern part of the Hills and the Bear Lodge range has been deposited in these rocks at the time of the intrusion, which was probably coeval with the elevation of the range, at the close of the Cretaceous period. But the gold-ledges in the schists and slates are of Archæan age, and formed during the folding of the metamorphic rocks.

There seems to have been no volcanic disturbance in the Black Hills since the elevation, and the occurrence of basalt capping gravel-deposits, so common a feature in the California and Australian gold-fields, is here entirely wanting. No fossil plants or the bones of extinct animals have as yet been found in the placers, whereby their age might be determined, but from their position they have been deposited not later than the Tertiary, and since the elevation of the Black Hills.

Very few minerals have been found associated with the gold, except garnets and magnetic-iron sand. The occurrence of zircon, topaz, or platinum, so common in the gold-washings in other parts of the world, has not been observed in the Black Hills.

With the exception of a few of the gravel-deposits in the foot-hills, which may be of shore formation, no deep leads or old channels filled with gravel were found, which could not be referred to the present streams and system of drainage, assuming only a greater rain-fall than at present, as numerous gravel-beds occur in dry sags and gulches, where water rarely, if ever, forms now a running stream.

There are evidences of four distinct erosions having taken place in the geological history of the Black Hills. The first at the close of the Archæan, the second during the early Tertiary, the third in the Drift or Glacial period, and the fourth, the result of the action of the present streams and drainage in recent times.

After the elevation and folding of the schists and slates, the formation of the auriferous quartz veins, and probably the intrusion of the granite of the Harney's Peak range, a most enormous denudation of the metamorphic rocks occurred, and the greater portion of the resulting material was swept away and lost. Only water-worn bowlders of quartz and the harder rocks remain, forming the conglomerate at the base of the Potsdam.

Most, if not all, of the area of metamorphic rocks was at one time covered by this conglomerate, and it is probable that the advancing Silurian ocean, at least in part, produced this erosion of the slates and schists. The conglomerate is often found to contain huge bowlders of quartz and quartzite derived from the ledges in the slates in the immediate vicinity, but nowhere were we able to find any pebbles of granite in the Potsdam, though fragments of soft clay, slate, quartzite, and quartz from its lower layers, and scales of mica are easily seen with a magnifying-glass in the compact layers of this sandstone. Granite occurs abundantly in the Tertiary and more recent conglomerate, and I can only account for this absence of granite in the conglomerate of the Potsdam by supposing that the feldspar yielded more readily to decomposition by the atmospheric agencies of the Silurian period than it has from the same forces since the elevation of the Black Hills.

The Potsdam commences with the coarse conglomerate, a deposit formed by a shallow and advancing sea, which seems to have gradually deepened, as the sediments forming the sandstone regularly become finer in grain as we ascend.

Since the Cretaceous, the Black Hills have been above the ocean-level, probably attaining their present altitude by a slight additional elevation at the close of the Tertiary, strata of that age, on the Cheyenne, having a dip of 3° to 5° from the direction of this range. From the Archæan to the Cretaceous, these sedimentary rocks are an evidence of denudation; of a wearing down of some continent, furnishing the enormous mass of material which now composes the extensive strata of slate, sandstone, limestone, and clay shales.

The second great erosion succeeded immediately the elevation of the Black Hills, and occurred during the early part of the Tertiary period. The resulting material forms the conglomerate between the top of No. 5 Cretaceous and the base of the Miocene or White River Tertiary. Only on the Cheyenne, between the mouths of Rapid and Spring Creeks, where this conglomerate, about six feet in thickness, caps hills of Cretaceous shales 500 feet in height, can the result of this erosion be identified. There the conglomerate is made up of small bowlders, round and water-worn, of granite, trachyte, slate, quartzite, and quartz, in all the varieties in which it is now found in the Black Hills, together with chert nodules from the Carboniferous limestone, and *fragments of* hard quartzite from the Cretaceous.

The third erosion occurred during the Glacial or Drift period, when thin beds of gravel, with occasional large bowlders, were strewn over the surface of the plains for a distance of fifty miles from the foot-hills, and rest equally on the surface of the different members of the Cretaceous and cap hills of the White River Tertiary. Some of these travelled bowlders are 2 feet in diameter, and are most abundant on the Cheyenne to the southeast of the Black Hills. They have evidently been transported by the agency of floating ice. Any current of water sufficiently powerful to carry bowlders of this size and weight would entirely remove and sweep away the soft clay shales on which they rest. There was no evidence found that during the Quaternary period any extensive glaciers occurred in the Black Hills. Even the tops of the highest peaks showed no glacial scratches where the hardness of the rocks would insure their preservation. A few large bowlders of granite, 8 to 10 feet in diameter, were observed perched on the tops of rocky benches at the bends of the small streams flowing southeast from Harney's Peak. They resemble those referred to glacial action in the Eastern States, but were possibly only the result of a peculiar weathering of the granite.

While there is little evidence of the presence of extensive glaciers in the Black Hills, the occurrence of large quantities of ice and snow in this elevated region during the Glacial period, with the necessary accompaniment of increased rain-fall and river action, have probably been the agents which have caused this immense denudation of the sedimentary strata. And it seems almost necessary to assume the occurrence of an extensive lake surrounding the Hills during the Quaternary period, when the bowlders resulting from the erosion were transported by the agency of the floating ice to the places where they are now found.

The whole area of the gold-field in the Black Hills was, at the time of the upheaval of the range, covered by the Potsdam and subsequent formations. It is probable that the Potsdam conglomerate, formed by the primary erosion of the metamorphic rocks and their inclosed auriferous quartz ledges, contains considerable quantities of gold, and, by the disintegration and denudation of this conglomerate since the elevation of the Hills, the gold which it contained has been set free and concentrated anew in the placer gravels. This may in part account for the richness of some of the older and more elevated gravel deposits along the valleys of the present streams.

The fourth erosion in the Black Hills has taken place in comparatively recent times—since the Glacial period—and is still in progress, modifying the effects of the previous denudation, and often removing and redepositing the gravel-beds resulting from them.

This last erosion is solely the work of time, frost, rain-fall, and river action, as they occur at the present time, all working extremely slowly, but gradually wearing down the rocks, deepening the valleys and cañons of the streams; and by working over the older auriferous gravels, increasing the richness of the bars and flats along the present beds of the streams. But the amount of gold swept into the valleys by the present forces and rain-fall must be inappreciable, compared with that resulting from the enormous tearing down of metamorphic rocks and quartz ledges by the previous erosions. The placer miners have a saying that "Gold does not go down stream at the present day," else we would look for it in beaver dams and other similar places. Though it is true that fine gold will sluice through a cañon over bare bed-rock, and be deposited in the bars below the mouth, it being only a question of time how long a particle of gold is making the journey, no matter how many times it may be caught on bed-rock, only to be liberated by

the wearing away of the rock or by freshets. Some of the richest placers found in the hills the past season were thus situated below the mouths of the cañons of the streams, where the valleys widened out, allowing permanent gravel deposits to form, retaining the gold.

In conclusion, in reviewing the gold placers of the Black Hills, it should be noted that at best the gold-field has been but partly prospected, and that it is extremely difficult to predict, even approximately, the value of any particular gulch or district until the gravel deposits have been completely opened and nearly worked out.

The causes and circumstances which have influenced the concentration of the gold in the placer-gravels are but little understood, and erosion has often removed entirely the ledges which were the source of supply of the gold now found in the gulches.

The deposits of auriferous gravel in the Black Hills may generally be said to be favorably situated for working, and that the gold can be very cheaply extracted, with the expenditure of but comparatively little time or capital in opening the deposits.

Compared with some of the world-renowned districts in California and Australia, the placers at present discovered are not remarkably rich, yet there are claims already opened and worked which are yielding a very good return for the labor employed.

At Cheyenne, the railroad is not more than two hundred and fifty miles from the gold-fields; the roads over which machinery and supplies are transported are excellent, the grades usually easy and the drives not long between water.

The climate of the Black Hills is wonderfully healthy and invigorating; wood, water, and grass are everywhere abundant and of the best quality.

There is gold enough to thoroughly settle and develop the country, and, after the placers are exhausted, stock-raising will be the great business of the inhabitants, who have a world of wealth in the splendid grazing of this region.

CHAPTER VI.

CLIMATE AND RAIN-FALL.

SECTION I.

It is extremely difficult, in fact almost impossible, to determine definitely the climate of the Black Hills from observations extending over a portion of a single year, especially as we were continually changing our location and altitude during the progress of the exploration, never being in any place more than a few weeks; but I have tried to give the facts as I observed them with all the possible collateral evidence based on the growth of plants, and trees, and the experience of previous explorers in this region. Naturally many obvious contradictions will be noticed, which I have in some cases tried to reconcile. In most instances I have given simply all the information that was collected concerning the climate and rain-fall of the Hills, that others, who have had greater and more extended experience than myself in the western country, might digest my data and judge for themselves, should they not feel inclined to concur with my deductions.

During the growing season, heavy dews were of regular occurrence at night, especially in the low bottom-lands along the streams, where the grass in the morning would be as wet as if it had rained hard for an hour. By experience we found it best to locate our camps on some slight elevation above the flats of the valley, to obviate the annoyance of having tents and camp-equipage saturated with dew on breaking camp early in the morning.

It is doubtful if there is a heavy snow-fall in the Black Hills. The miners who remained in the Hills during the winter of 1874–'75 report that there was never more than six inches of snow on the ground until April, when a heavy fall occurred at the time they were removed by Capt. John Mix.

In a few localities in the interior of the Hills I saw small trees which had been bent down by snow-drifts, but the streams showed no traces of freshets caused by snow melting in the spring. There was no drift-wood along their banks, and the bridges built by General Custer the previous summer were still in place, which a rise of a few inches would have swept away. The snow must be sometimes deep enough to hide trails and landmarks, as the main Indian trails leading through the Hills were marked by stones placed in the forks of the trees or by one or more sets of blazes, the oldest almost overgrown by the bark.

No hail-storms occurred in the Hills the past summer which caused any injury to vegetation. Often during thunder-storms it would hail for a few minutes, owing to some sudden change of temperature in the storm. The central portion of the Hills is elevated from 2,000 to 3,000 feet above the foot-hills, or an altitude of 5,000 to 7,000 feet above the sea, and necessarily the weather is sensibly cooler. The thermometer seldom stands above 85° Fahrenheit in the shade. In this elevated region thin ice formed occasionally at night in open dishes of water left exposed to the sky even in midsummer, and after September 1 thin ice formed nearly every night in still pools. This low temperature occurred just before daylight and was of short duration. It was owing to the

great radiation and evaporation due to the rarity of the air, and the clearness of the sky causing no corresponding reflection of heat back to the earth. It seemed to have no bad effect on vegetation, which flourishes bright and green until about September 8, when the first frosts began to change the color of the leaves of the plants.

The growing season in this elevated region is necessarily but a few months. June 10 the aspen trees at the head of Floral Valley, at an altitude of 6,600 feet, were just bursting into leaf, the grass was green but quite short, and by September 8 the plants in this same valley were colored by the frost, and vegetation, except the evergreens and grass, had ceased to grow.

From the equable temperature and pure air, the climate was found to be remarkably healthy. Scarcely any one was sick in the whole command during the time we remained in the Hills.

The temperature of many springs of water issuing from the Carboniferous limestone and the granite and metamorphic rocks in the central and elevated portion of the Hills was found to average 42° Fahrenheit, even in midsummer. The springs bursting out among the foot-hills at the edge of the plains were not tested with a thermometer, but apparently the water was not as cold by several degrees.

Col. Richard I. Dodge, commanding the escort of the expedition, a close observer of nature, publishes the following article on the climate of the Black Hills, which is so excellent that I take pleasure in quoting it entire:

The climate is sufficiently varied to suit the tastes of almost any person or class. We have no knowledge of the winter climate, except from the reports of the miners who built the stockade and passed several months of last winter on French Creek. These unite in commendation. The winter was cold, but clear; the temperature remarkably equable. There were no storms of any disagreeable magnitude, and the first serious snow-storm occurred just before they were brought out, in March.

It is hardly fair to judge, even of spring and summer climate, by the experiences of a single year, more especially since we were almost continually moving, changing not only our position but our altitude. If, however, the experiences gained under such circumstances are to be regarded even as approximate tests, I can pronounce the climate of the Black Hills well-nigh perfect. Scarcely a day was too hot; scarcely a night so damp or cold that we could not sit out and enjoy ourselves around the campfire.

There is no such thing as a hot night. Though extremely susceptible to heat, I slept not a single night in the Hills under less than the equivalent of two blankets, and many times, even in midsummer, I required more.

I have already mentioned that on the 10th day of June we encountered, in the elevated gorge named by Custer "Floral Valley," a sharp snow-storm, alternating with sleet and rain. This valley is more than 6,000 feet above tide-water. On French Creek, at an elevation of 5,800 feet, we had a severe, killing frost on the night of the 10th of August. There is abundant evidence that the season, in these very high altitudes, is too short for an agricultural country.

For five weeks, from 14th June to July 20, Camp Harney, on French Creek, was the center of operations of our exploring and surveying parties. We had, therefore, a much better knowledge of its climate than of any other portion of the Hills. It is 5,620 feet above tide-water. The climate is superb. Though it sometimes felt hot by day and damp and cold by night, the thermometer was never above 78° nor below 54°. A series of observations (not so regular as might be wished) gave a mean temperature of 62° and a daily variation of 14°. A few similar observations at Camp Crook, on Rapid Creek, in the latter part of July, resulted in a mean temperature of 64°, with a daily variation of 20°. On the 24th of July, on Rapid Creek, a severe hail-storm sent the mercury from 84° to 62°, 22°, in half an hour. Camp Crook is at least a thousand feet lower in altitude than Camp Harney.*

The past winter of 1875–'76 has been unusually mild all through the Northern and Western States, and reports from the miners in the

* The Black Hills, by Richard Irving Dodge, Lieutenant-Colonel United States *Army*. New York: James Miller, publisher, 647 Broadway, 1876.

Black Hills speak in glowing terms of the delightful weather they have experienced; very little snow having fallen before February, the grass being green at the roots, and the stock, when not overworked, keeping fat and in good condition. The winter of 1874–'75 was correspondingly extremely severe; yet the Sioux City party of miners who built the stockade and cabins on French Creek, in December and January, report that the cold was not intense, and that their cattle kept fat on the grass in the vicinity, where the altitude is 5,600 feet above the sea.

The Black Hills, with their copious rain-fall, rise like a high wooded island from an ocean of grass-covered and treeless plains, watered by occasional and scanty rains. The rain-fall on the plains, far from yielding a constant and uniform supply of moisture, unfortunately is very uncertain and irregular, both in quantity and occurrence, and sometimes falls so far below the average that the grass almost perishes from the drought.

This arid character of the plains is not peculiar to the region immediately about the Black Hills, but is equally true in a general way for this whole belt of elevated plains, nearly five hundred miles in width, extending along the eastern slope of the Rocky Mountains from Mexico to the British Possessions. And the reason for the treeless character of this immense tract of country is to be sought in its location with respect to the adjacent ranges of the Rocky Mountains, and to the oceans on both sides of the continent.

From the north the winds, coming from the colder regions in the British Possessions, bring with them scarcely any moisture; while from the south, the direction of the prevailing winds and the character of the country is such that any supplies of rain from that direction are cut off. The winds which sweep over the Pacific Ocean are chilled by contact with the elevated ridges and snow-clad peaks of the Rocky Mountains, and precipitate the moisture which they contain as rain or snow. Passing on, these winds descend on the heated surface of the level plains, where, in summer, the temperature is often as high as 100° Fahrenheit in the shade. Becoming heated and rarified, they sweep eastward to the Missouri, having their capacity for holding moisture greatly increased, and no ordinary change of temperature will cause these winds to part with the little moisture which they possess. Thus it will be seen that, practically, these plains have to depend for their rain-fall on the supply of moisture derived from easterly winds coming from the Atlantic Ocean and the Gulf of Mexico. These winds, in passing over the Alleghanies and the Mississippi Valley, have been subjected to innumerable changes of temperature, and robbed of the greater portion of the moisture they originally contained, to the serious detriment of this immense belt of country. As would be expected from the above, it was noticed the past season in the Black Hills that the rain-storms of long duration were preceded by, or occurred during, the prevalence of easterly winds, which were chilled by contact with the colder and more elevated portion of the Hills, precipitating the moisture which they carried.

While encamped on Rapid Creek, near the edge of the plains on the eastern slope of the Hills, I had an excellent opportunity to observe the formation and condensation of rain-clouds during the succession of rainy days in July. The wind was blowing gently from the east and southeast. Out on the level plains it scarcely rained at all, though dense banks of clouds hung over them, and detached masses of mist and fog were sweeping low over the more elevated foot-hills. The clouds would form over the plains and, drifting on to the Hills, conceal from view the highest peaks and ridges, chill, settle down to the level of the

valleys, and immediately rain until the excess of moisture was precipitated; then rise and drift away, when a short interval would occur before the clouds would again sweep in and produce a shower.

On examining the accompanying maps of the Black Hills, it will be seen that nearly all the streams rise in the central or western portion and flow east, the slope of the country being in that direction. I think that this eastern slope of the Hills has a greater rain-fall than the western, judging from the growth of plants and trees, a fact which would coincide with the theory that the rain-producing winds came from the east and precipitated their moisture on that slope.

But the showers of rain and the thunder-storms which we so frequently experienced seemed to be independent of the easterly winds as a source of their moisture, and to be local in their origin and occurrence. Generally of short duration, they came usually from the west and passed rapidly by, raining hard for ten to twenty minutes, and leaving the grass and trees dripping with moisture and refreshed by their passage.

The winds which blow on the Hills from any direction pass over the plains for a great distance, and, gathering some moisture, part with it on being chilled by contact with the cold and elevated peaks in the interior. Thus the Black Hills may be said to have a local and limited rain-fall not directly dependent on the easterly winds, which, nevertheless, furnish the greater supply of moisture.

The rain-fall experienced in the Hills during the progress of the survey, was very remarkable for the frequency and regularity of the showers and their short duration. It was varied by the occurrence of occasional long steady rains and damp, drizzly, or foggy days. From June 1 to August 1 it rained more or less, at least twenty days in the month. Usually the sky would be overcast by clouds about 3 or 4 o'clock in the afternoon. A smart shower, lasting from a quarter to half an hour, would rapidly pass by from the west and the sun would shine again and quickly dry up the ground. On one occasion I experienced, near Harney's Peak, four distinct showers accompanied by thunder and lightning in a single day, which was otherwise warm and pleasant, the sun shining brightly except when it was raining. It was not unusual to have a shower during the day followed by another after midnight. After August 1 the showers were not so numerous and the rain-fall was appreciably less, although several rainy days occurred in both August and September.

Referring to my note-book, I find the following record of the rain-fall observed while prospecting on Rapid and Spring Creeks:

June 26, rained steadily all the afternoon.
June 27, a shower in the afternoon.
June 28 and 29, no rain where we were camped.
June 30, rained steadily all day, preventing any work being done.
July 1, two showers during the day.
July 2, 3, did not rain.
July 4, rained hard all day.
July 5, rained hard for half an hour in the afternoon.
July 6, showers all around on the Hills, but did not rain where we were.
July 7, 8, no rain
July 9, 10, 11, 12, 13, 14, 15, one or more showers each day, usually after 2 p. m.

From the above it will be seen that it rained fifteen days out of twenty-two. Referring to the published reports of the expedition to the Black Hills under command of Gen. G. A. Custer, in 1874, I find

that Colonel Ludlow mentions this fact of the frequent occurrence of showers in the afternoon, under date of July 27, while encamped on the head Castle Creek, a branch of Rapid.

This portion of the Black Hills never suffers from drought. No arid places are seen except on the summits of the limestone ledges. Springs are numerous, and very cold and pure. The soil is everywhere moist, and vegetation marvelously luxuriant and fresh. The warm currents of air from the plains condense as they ascend the slope of the hills, and robbed of their moisture in fog, rain, and heavy dews, which occur nightly. The clouds almost invariably formed in the afternoon, and interfered greatly with astronomical observations. (Report of a reconnaissance of the Black Hills of Dakota, made in the summer of 1874, by William Ludlow, captain of engineers, &c., page 13.)

Gen. G. A. Custer and Major Forsyth also mention, in their reports of the expedition, the refreshing showers of rain which were frequently encountered, and also the thick fogs, prolonged rains, and severe thunder-storms experienced while in the Hills. That this remarkable rain-fall, which was observed throughout the Black Hills during the progress of the exploration, was not the exhibition of a peculiarly wet season, I can only judge from the evidence given above by previous explorers during the preceding year, and by such observations as I was enabled to make on the growth of plants and trees. In many places I noticed plants whose habits of growth I was well acquainted with, which require a considerable and regular supply of moisture for their maintenance, growing on dry, rocky hill-sides exposed to parching winds and the heat of the sun, and flourishing and producing flowers and seed in perfection. On the tops of the mountains, near Harney's and Custer's Peaks, far above the level of any springs of water, I found patches of wild raspberries growing so thickly that the ground was covered with them. The bearing-canes, which are of a previous year's growth, were of full size and loaded with fruit, showing that the previous season had been equally favorable to their development. All along the eastern slope of the Hills burr-oak and elm trees, which require an abundance of moisture to sustain their growth, attain at least a medium size, and are found not only along the banks of the running streams, but growing in small grooves on the hill-sides and in the swales and valleys. On examining the pine timber in different parts of the Hills I found that the annual rings of growth were uniform in width. The coarseness of the grain of the timber, its softness, and the regular appearance of the full-grown trees, all indicate, independent of the species of tree, a uniform yearly growth, and consequently a regular rain-fall. From these evidences I think I may safely draw the conclusion that the season of 1875 in the Black Hills, which I witnessed, was not an unusually wet one, although the rain-fall may have been somewhat above the average. The average amount of rain for the plains surrounding the Black Hills does not, probably, exceed 15 inches for the whole year. To the north, in the valley of the Upper Missouri, it is about 12 inches.

From the nature of the work the past season, it was impracticable to definitely determine the *amount* of rain-fall; but the presence of trees indicates conclusively that it must be at least 25 inches, and not fall much below that amount for more than a single successive season, or many of the trees would perish from want of moisture. The following tables, giving the rain-fall in inches for the nearest localities to the Black Hills where observations have been made, are from the Smithsonian tables and the records of the Signal-Service of the United States Army:

Mean amount of precipitation of moisture, as rain and melted snow, for each month in the year.

Name of station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Fort Randall, Dak	0.49	0.42	0.99	1.10	2.67	2.30	1.76	2.56	2.43	1.09	0.41	0.30
Fort Pierre, Dak	0.50	1.18	0.46	1.63	2.19	0.48	1.18	1.66	1.29	1.08	1.39	0.47
Fort Abercrombie, Dak	0.52	0.66	1.03	1.82	1.82	2.18	3.01	2.30	1.07	1.30	0.99	0.64
Fort Laramie, Wyo	0.61	0.46	0.84	1.06	3.74	1.90	1.63	1.37	1.17	0.97	0.84	0.57

Mean amount of precipitation of moisture, as rain and melted snow, for the season and the whole year.

Name of station.	Spring.	Summer.	Autumn.	Winter.	Year.	Extent of series.		Date.	
						Years.	No.	Beginning.	End.
Fort Randall, Dak	4.76	6.64	3.90	1.21	16.51	8	10	1857	1867
Fort Pierre, Dak	4.28	3.32	3.76	2.15	13.51	1	10	1855	1857
Camp Abercrombie, Dak	4.67	7.49	3.36	1.82	17.34	6	11	1860	1867
FortLaramie, Wyo	5.64	4.90	2.98	1.64	15.16	12	6	1849	1864
Cheyenne, Wyo	3.11	5.56	1.98	0.37	10.02	4	4	1871	1875
Fort Buford, Dak	.....	6.49	.....	.....	11.75	8	0	1867	1874

It will be noticed, from a comparison of the above tables, that the rain-fall for the whole Upper Missouri region follows the same general law, being greatest in the spring and summer months, from May to September, and last in autumn and winter, coinciding with the observations made in the Black Hills the past season. The season of 1875 was remarkably wet generally throughout the United States. At Cheyenne and North Platte on the Union Pacific, 220 miles south of the Black Hills, the rain-fall was not above the average, but at Yankton and Bismarck, Dakota, situated nearly an equal distance north and east, it was unusually great, as is shown in the following table, compiled from the records of the Signal-Service United States Army:

Name of station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Year, 11 months.
Cheyenne, Wyo	0.42	0.06	0.23	0.50	1.20	0.29	4.47	2.12	1.34	0.60	0.84	12.07
Yankton, Dak	1.07	1.51	1.79	5.26	2.04	2.21	5.53	4.95	5.33	0.14	0.12	36.95
Bismarck, Dak	1.05	1.32	2.06	4.22	3.40	5.02	1.53	2.89	1.85	2.37	1.33	27.04
North Platte, Nebr	0.24	0.26	0.40	6.21	1.69	1.62	2.12	0.66	1.40	0.14	0.52	15.26

Severe thunder-storms prevail in the Black Hills during the summer months. The clouds, instead of floating high in the air, sweep low over the elevated ridges, and the lightning is consequently peculiarly liable to strike the ground rather than to pass from one portion of the cloud to another and harmlessly expend its force. This causes some damage to the timber of the region. Often, in riding through the Hills, trees showing unmistakable marks of lightning would be seen, generally with the top shattered and a strip of bark about an inch wide torn out in a straight or spiral line from the top of the tree to the ground. Sometimes, however, only the splintered stump of what had once been a large tree remained, while the ground all around was strewed with fragments of the trunk, branches, and limbs.

It would seem that the pines growing in certain portions of the Hills were peculiarly liable, for some unknown reason, to be struck by lightning. On a hill, near the headwaters of Spring Creek, I counted twelve trees, growing on about two acres of ground, that were marked by lightning, and in a small park near by, among about one hundred trees, fourteen had been struck in previous years, some of them more than once. The most severe thunder-storms came from the west and traveled in an easterly or southeasterly course, the storm commencing with gusts of wind from the west, shifting to the north and northeast in the height of the tempest, and finally, as the storm passed by, blowing from the east or southeast.

A most terrific thunder-storm was encountered by myself and a small party of miners while camped on Box Elder, August 7. The day had been pleasant but somewhat warmer than usual. About 3 o'clock in the afternoon a dense black cloud, extending like a wall across the valley, and rapidly advancing from the west, warned us of the approaching storm. Hardly had we completed our preparations to protect ourselves and provisions from the rain, when, preceded by violent gusts of wind that nearly prostrated every tent, the storm burst upon us. The rain, impelled by the violence of the wind, descended almost horizontally, and beat in torrents against the sides of the tents for about five minutes. Then, suddenly the wind shifted to the north, and came in sudden squalls of cold, piercing wind, chilling us through in a moment, and changing the rain instantly to hail, which was piled in winrows against every projection on the ground. Quickly veering back again to the west, the rain came, mixed with hail, driving before the blast. And then the storm raged with all its fury; flash after flash of chain-lightning followed in quick succession, extending vertically from the low, overhanging cloud to the ground, and striking at nearly every discharge among the trees on the surrounding hills. The thunder was incessant, and the crashing, increased by the reverberations from the surrounding rocky cliffs, was so continuous that it could not be referred to any particular flash. The wind shifted nearly all around the compass in the direction of the motion of the hands of a watch. The storm passed by in half an hour, the last rain coming from the southeast. The sun shone brightly once more, while to the east, down the valley, the cloud could be seen hiding everything from view, but illuminated every moment by flashes of lightning extending to the ground. On examining several dishes which had been left out in the rain, I found that in about twenty to thirty minutes an inch of water had fallen. One of the miners came into camp shortly afterward and reported that he had been caught out on the top of a neighboring hill during the storm, and that two trees near him were struck by lightning and thrown to the ground in fragments. The Indians are said to desert the Hills in the summer on account of the lightning, and I can easily understand that a band of superstitious Indians, after experiencing such a storm, especially if any of their number were injured by the lightning, would forever forsake the locality.

CHAPTER VII.

NATURAL RESOURCES OF THE BLACK HILLS.

SECTION I.

WATER.

To a settler in a new country no question is of greater importance than the purity and abundance of the supply of water; and in this respect the Black Hills are unequaled by any region in the "Great West."

A glance at the map shows, by the innumerable branches of the creeks and the intricate nature of the topography, that it is an extremely well-watered country. Springs are found in almost every ravine. Nearly all the small head-branches of the creeks are running brooks of pure water; and streams of considerable size, and but a few miles apart, drain this region, affording a constant and regular supply of water for both stock-raising and mining purposes.

The creeks which drain the gold-field rise in numerous small springs, issuing from the granite and metamorphic rocks, and the water is consequently remarkably pure and free from mineral or organic matter. Those branches which head in the great Carboniferous limestone, yield water suitable for most domestic purposes, the only drawback being a slight "hardness" due the presence of carbonate of lime, which does not in the least affect the health of those using it.

Only among the foot-hills, where the gypsum of the Red Beds or the "alkali" derived from the Jurassic and Cretaceous shales has contaminated the streams draining these formations, is the water found to be unfit for cooking purposes, and possessing purgative properties. Elsewhere throughout the whole area of the Black Hills included within the timber-line at the edge of the surrounding plains the water both of the springs and running streams is clear, cold, delicious to the taste, and extremely healthy. Early in June the temperature of the springs at the head of the Floral Valley was found to be 39° F., the elevation being 6,600 feet above the sea. In midsummer the water of a number of springs in the interior of the Hills was tested with an accurate thermometer, and found to vary between 42° and 44° F. After August 1, the past summer, the volume of all the streams in the Black Hills was somewhat diminished by the partial cessation of the heavy rains, but none of the creeks stopped running, except that portion of French Creek above the Stockade, where the springs supplying the water are small and the grade very slight. From the character of the geological formations outcropping in the foot-hills and along the edge of the plains, all the streams rising in the Black Hills sink in their beds and disappear before passing through the belt of Carboniferous limestone, with the exception of Rapid Creek, which flows into the Cheyenne, and Spearfish and Redwater, which empty into the Belle Fourche. Large springs of good cold water burst out from under the Triassic Limestone in the Red Beds at intervals along the inner rim of the broad Red Valley encircling the Black Hills. These springs will be very valuable to the future stock-raisers in this region, affording watering-places for the stock grazing in the open plains or among the foot-hills.

Spearfish and Redwater pour united a large volume of excellent

water into the Belle Fourche, but the shales of the Cretaceous formation through which the river flows soon contaminate the water with alkali, giving it a slightly unpleasant taste, and causing it the past autumn to seriously affect the health of the escort. Probably at other seasons the water of the Belle Fourche deserves its name and reputation, but at the time we were camped on its banks (September 20) the stream was comparatively low and the water contained its maximum of impurities. The South Fork of the Cheyenne is like most of the rivers in the plains, shallow, with a moderate current flowing through a broad, level bottom, yet subject to sudden rises in spring and early summer. In places it cannot be forded on account of quicksands, even when the river is so low that the water is but a few inches deep.

The water of the Cheyenne is full of suspended mud, and contains traces of alkali derived from clays along its banks.

SOIL.

There is no better way to judge of the fertility of the soil of a new and unsettled region, where the rain-fall is abundant, than to examine the growth and character of the vegetation which it supports.

The Black Hills are an oasis of verdure among the open and level plains. A luxuriant growth of grass spreads over the whole region; even on the rocky hillsides grass is found growing in the crevices in the rocks wherever there is a particle of soil for its support. A heavy forest covers the greater portion of this area, the trees growing thickly together and attaining full size, not only on the rich bottom-lands of the valleys but on the tops of the level limestone "mesas;" and the steep rocky ridges are clothed with pine of good size to their very crests. The soil on the main divides and ridges is not so deep as it is in the parks and valleys which have received the wash from the neighboring hillsides, and these elevated tracts, being most valuable for grazing purposes, will not be used for cultivation.

Even a casual examination shows that the soil of the valleys, the broad swales of the parks, and the bottom-lands along the creeks is exceedingly rich and deep, being a dark-colored loam, resulting from the decomposition of the granite, limestone, and schistose rocks occupying the central area of the Hills. Often in sinking prospecting-pits along the valleys in search of gold, the soil would be found to be a black peaty loam from 2 to 3 feet in thickness, and frequently in the bottom-lands the soil was 4 feet in depth, resting on a gravelly subsoil.

In the parks and along the elevated limestone divide, near Crook's Tower, are numerous swales of rich grass-land between the low hills and ridges. The soil is deep and fertile, supporting a rank growth of herbaceous plants, but owing to the elevation above the sea and the short growing season of not more than three months, the value of these tracts for cultivation has yet to be proved by experiment. In the valleys of Spring and Rapid Creeks are extensive bottom-lands, which would be excellent for farming purposes, did not the underlying gravel contain gold in quantities sufficient to cause it to be mined out in the next few years to the ruin or serious detriment of the land.

The whole valley of Rapid Creek, a mile and a half wide, from the foot-hills to the Cheyenne, a distance of 45 miles, is susceptible of irrigation from the stream, which carries at least 3,000 miner's inches of water in midsummer. The soil of this valley is deep and fertile, except near the Cheyenne, among the clay shales of the Cretaceous, where the presence of alkali makes the grass thin and poor.

There are extensive tracts of good farming-lands on the Redwater and Spearfish, near where they unite to form the Deep Water, a branch of the Belle Fourche. Colonel Dodge, the commander of the escort, regarded this locality as admirably suited for a military post.

The soil of the upper valley of the Belle Fourche, from Bear Lodge Butte to the point where it suddenly bends to the southeast, is reported by the topographical party to be excellent, and that broad flats of grass-land skirt its banks for miles. The valley of this stream, below where it is joined by the Deep Water, is injured by the prevalence of black Cretaceous clays and the usual accompaniment of alkali.

The South Fork of the Cheyenne has a broad, level bottom, but generally so little elevated above the water in the stream as to be liable to inundate from floods. In places, however, some very good land is to be found in extensive flats along that stream. Were the Black Hills as densely populated as the State of New Hampshire or Vermont, which they resemble in the character of the vegetation and climate, a very considerable proportion of the area would be subjected to cultivation. But the amount of arable land, or rather land that will in the next quarter of a century be cultivated in this region, is small, compared with the whole area of fully six thousand square miles embraced in the Black Hills. There is good land enough in the bottoms of the streams, suitable for cultivation, to amply support the population, which will remain in the hills after the present excitement shall have subsided, and stock-raising become an established occupation.

Including the bottom-lands of the Cheyenne and the Belle Fourche, and the arable land along the valleys of the streams issuing from the Black Hills, I estimate that not less than one-twentieth of the whole area is susceptible of cultivation, the remainder being covered by forest or forming stock-ranges of the finest description.

WILD FRUITS.

The fruits found growing wild in the Black Hills are an evidence of the adaptability of the country for raising the more valuable cultivated varieties, and hence I propose to consider the wild fruits which were found in this region much more in detail than they would otherwise deserve. The most useful is the red raspberry, which was found in large patches in the vicinity of Terry's Peak, at an elevation of 6,500 feet above the sea. The plant is rather dwarf in size, the bearing canes being about 2 feet high, and August 15 were loaded with delicious fruit, resembling very closely the cultivated variety "Knevit's Giant" in size, flavor, and productiveness.

A variety of black gooseberry was abundant on the western side of the hills, near Inyan-kara; the fruit was of a pleasant acid flavor and of good size, only differing from the ordinary western wild gooseberry in being blue-black in color, instead of dark red.

Several species of currants, including the black, red, and fetid varieties, were occasionally seen, but are valueless.

The wild western strawberry grows throughout the Hills. It is a very shy bearer, and the fruit is deficient in flavor.

The bunch-berry, or cornel. (*Cornus canadensis*,) was found in the extreme northern part of the Hills. I have never seen it elsewhere, except in Maine and Nova Scotia.

Service-berries (*Amelanchier canadensis*) were quite plenty on Spring and Rapid Creeks in July. The common wild red plum grows in

patches among the foot-hills, along the bottoms of the ravines. The fruit was ripe about September 20.

The only variety of grape noticed was a kind of frost-grape, found along the banks of the streams, near the edge of the plains.

Quite extensive patches of the two varieties of hazel-nuts were observed in the southeastern part of the Hills, associated with alder, white birch, iron-wood, white elm, burr-oak, sumac, the poison ivy, (*Rhus toxicodendum*,) the Virginia creeper, and many other plants of wide range and distribution.

Wild flax and wild hops attain a rank and luxuriant growth on the bottom-lands along the streams, and the soil and climate seem to be remarkably well suited to the growth of these plants.

The flora of the Black Hills bears quite a resemblance to that of Southern Maine and New Hampshire in the same latitude, and it is probable that many of the agricultural productions, fruits, and vegetables which can be grown in perfection there will also succeed in favorable portions of this region. The luxuriance with which the heavily-seeded grasses known commonly as "wild rye," "cheat," and "wild oats" grow on the rich bottoms along the eastern slope, would indicate that an equally rank growth of the cultivated cereals and grasses is to be expected. Except at a low elevation among the foot-hills near the edge of the plains, the nights will probably be found too cool for the successful growth of Indian corn, which is a tropical plant, but oats, rye, barley, and wheat should yield well, and potatoes of the best quality may be produced in the fertile valleys.

GRAZING.

The grazing in the Black Hills is most excellent. Nine-tenths of the whole area is covered by a thick growth of the finest wild grasses. It constitutes the great future wealth of this region, and its value can hardly be overestimated.

Every one who visited the Hills the past season was enthusiastic over the luxuriance of the grass, which in the brightest green spreads over the surface of the parks, hill-sides, and valleys, adding greatly to the beauty of the scenery.

Cavalry officers, herders, scouts, and miners all were united in praise of the grazing. "California Joe" said of the valley of Spring Creek: "There's gold from the grass roots down, but there's *more gold* from the grass roots *up*." And no matter how rich the gold-placers in the Black Hills may prove to be, the great business in this region in the future will be stock-raising and dairy-farming.

Owing to the heavy dews at night during the growing season, to the frequent thunder-showers, and the occurrence of occasional long and heavy rains, the grass grows all over the Black Hills wherever it can obtain a particle of soil for its support and a few hours' sunshine during the day.

Even in the clefts of the rocks, the sides of the steep ridges, and in the bottoms of the deep cañons, grass is found growing, depending on the scanty soil for its sustenance, and the little sunlight that pierces through the dense branches of the trees or penetrates for a short time the depths of the gorge.

Unlike the grass on the plains, which springs up in May and by July has turned yellow and cured to a natural hay, the grass in the Black Hills, stimulated by the abundance of moisture, continues growing all

through the summer, remaining always fresh and green until its growth is checked by the frosts of autumn.

When the expedition reached the Hills, about June 1, spring was well advanced. The trees on the foot-hills were in full leaf, and the grass had evidently been growing for several weeks. On the top of the Beaver Creek plateau, at an elevation of 6,000 feet above the sea, the grass (June 5) was six inches high, and covered the whole surface of the level mesa, growing thickly under the shade of the pine forest, even to the very roots of the trees, giving the region the appearance of a smooth, well-kept lawn, with tall pines rising from the green carpet of grass.

The grasses in the Black Hills are almost endless in variety, every condition being so extremely favorable to their growth. In the interior of the country the shorter grasses prevail. But among the foot-hills on the rich bottom-lands of Rapid Creek the taller grasses known as "wild rye," "crow's foot," "cheat," and wild oats attain a luxuriant growth. The "grama," or "buffalo grass," covers the valleys at the edge of the plains to the exclusion of the other varieties. It is considered the most nutritious wild grass in the western country, curing to hay on the ground. But, when growing in an alkaline soil, it seems to rapidly lose its nutritive qualities after the seed ripens. Along the banks of the streams, where the soil is marshy, large patches of the scouring rush are found growing. It forms an excellent food for stock, for which they will desert the finest grasses, and feed upon it until they are full and can eat no more.

I had previously been engaged in explorations in Western Texas and New Mexico, but I was surprised at the quality of the grazing we found in the Black Hills, which resembled the grass growing in the oak-openings in Central Texas, except that it was finer and freer from weeds and the coarser and less nutritious grasses. The escort of the expedition remained camped on French Creek for six weeks, and grazing for nearly one thousand horses and mules and three hundred head of cattle was found during that time within a mile and a half of camp, the grass commencing to grow again as soon as it was eaten off by the stock. For the requirements of the population that the Black Hills will support in the next twenty years, enough hay can be procured from the wild grasses; and should the demand in the future increase, an ample supply can be raised by sowing timothy or other cultivated varieties on the bottom-lands of the valleys. The best localities for hay are in the southeastern part of the Hills, on Amphibious, French, Spring, and Rapid Creeks, and in the valley of Rapid, between the foot-hills and the Cheyenne, where the taller grasses are abundant on the moist bottoms of the streams and side valleys.

On the plains in the valleys of the Cheyenne and the West Fork of Beaver Creek there are localities where sage-brush and "prickly pears" cover the alkaline soil, and grass is only to be found in patches. But generally throughout the area of the Black Hills the grass uniformly covers the land, wherever there is soil for its support and the shade is not too dense for its growth. Except among the Red Beds in the foot-hills, sage-brush is never seen and cactus but rarely met with.

Over thickly-wooded areas, and in the mountainous and rocky region about Harney's Peak, the grass is found only in patches in the few localities favorable for its existence. A similar region, comparatively destitute of grass, occurs in the northern part of the hills between Terry's and Crow Peaks, where the whole surface of the country is cut into innumerable cañons, and a species of ground-ivy, called "kinnikinnick," a plant probably of the dog-wood family, replaces the grass.

I estimate the total area of country destitute of grass, or where it

only occurs in isolated patches, to be not more than six hundred square miles, or one-tenth the whole area of the Black Hills, the remaining five thousand five hundred square miles constituting some of the best ranges for cattle, horses, and sheep to be found in the whole western country.

Cattle frequently perish on the plains in large numbers during the severe winters, not so much from the low temperature or intensity of the cold as from the piercing winds, accompanied by sleet or snow, that sweep with resistless fury over the level and unbroken surface of the ground, chilling the animals more than any ordinary degree of cold could possibly affect them in a more sheltered locality. In the Black Hills the wind may blow a gale over the mountain-tops and exposed ridges, but in the valleys the air will be comparatively at rest, the timber covering the hill-sides and ridges materially contributing toward making the valleys warm and sheltered. This will be of great advantage to the stock which may be wintered in the Hills, shelter being found everywhere from sudden or severe storms. The grass exposed on the hill-sides by the snow blowing away or melting, as well as the green twigs of the bushes and trees, will afford subsistence for the cattle during any heavy fall of snow.

The miners who have passed the winters of 1874–'75 and 1875–'76 in the Black Hills, report that the grass remained green at the roots, and afforded good grazing, keeping the stock in good condition, if it were not overworked. Little snow was experienced until the early spring months, when the first heavy falls of snow occurred.

From the secluded and sheltered character of the valleys, the abundance of water, and the fine quality of the grazing, the Black Hills are well adapted for dairy-farming, the establishment of cheese and butter factories, and the raising and breeding of fine breeds of cattle and sheep.

The Black Hils are remarkably free from noxious insects, and grasshoppers and locusts are rarely met with in numbers sufficient to cause any appreciable damage to the grazing or vegetation. Only in one locality were they at all numerous. On Beaver Creek, in the southwestern portion of the Hills, near the plains, early in June grasshoppers were just hatching, and in a few weeks had grown large enough to strip the leaves from the bushes. Gnats and mosquitoes were sometimes found in the Hills, but never in numbers to cause any annoyance. Large flies were quite troublesome during a few weeks in July and August, but the first cool nights caused them to disappear.

TIMBER.

The Black Hills are a well-wooded country. The plenteous rains and showers in summer keep the vegetation growing unchecked by drought. The density of the forests clothing the hill-sides have, from their somber hue, when viewed from a distance, given the name to this region, the "Black Hills," by which it is known also in the Indian dialects.

The following trees will yield timber in this section :

The heavy pine, (*Pinus ponderosa,*) often known as yellow or Norway pine, the most abundant and valuable tree in the Hills.

Black and white spruce, found among the valleys in the central and northern portions of this region, covering a considerable area.

Burr oak, (*Quercus macrocarpa,*) in small groves on the eastern slope, near the foot-hills.

White elm, (*Ulmus Americana,*) associated with the burr-oak, occurs along the valleys of the streams near the eastern and southeastern foot-hills.

Aspen, white birch, ash, mulberry, box-elder, (*negundo*,) iron-wood, (*horn-beam*,) and juniper grow sparingly in different parts of the Hills, but are of little comparative value.

The pine forests cover so extensive an area and will yield so large a proportion of the timber that all the other trees combined may be neglected in comparison, though they will be found valuable in the future development of the country. The "Norway pine" is a tall, straight tree, free from limbs for one-half its height from the ground. The wood is white, soft, with a straight, somewhat coarse grain, free from knots, and splitting readily into "shakes," shingles, or other similar forms. The sap is more resinous than that of the white pine, and in this respect this variety approaches more nearly the pitch-pine of North Carolina, a tree which it somewhat resembles in its style of growth.

The transverse strength of the wood is not so great as that of white pine, but by proper care in using it in construction this deficiency can be compensated for and practically obviated.

On the bottom-lands in the lower valley of French Creek, specimens of this pine were seen that were fully 100 feet in height, and would measure 35 to 40 inches through at the ground. Trees of these large dimensions are, however, rare in the Hills. Timber of from 12 to 24 inches diameter is common, while extensive tracts are covered by a dense forest of small slender pines from 50 to 60 feet high, and rarely less than 8 or more than 12 inches through at the ground.

The pine forests in the Black Hills, where the trees are of mature growth and uninjured by wind or fire, will furnish good straight saw logs from 30 to 50 feet in length and very uniform in thickness, with a gradual taper, averaging in diameter from 12 to 20 inches.

The tall slender pines will be very useful to the settlers in this region, being well adapted for fencing and house-building purposes. The resinous character of the wood makes it a most excellent fuel, burning with a long smoky flame, giving out an intense heat, almost equaling in this respect the pitch-pine of the Southern States.

On the tops of the ridges and hills, where the trees are exposed to the violence of the storms, the timber is wind-shaken and injured in quality; but on the more sheltered hill-sides, the broad level mesas, and in the numerous valleys and parks, the trees are free from this evil, and are remarkably straight and regular in growth. Pines were sometimes encountered blown down by the wind, across the narrow ravines, the trunk of the tree, even when 1 to 2 feet in diameter, being broken short off by the violence of the fall on the rocks. This rarely happens with the spruce under similar circumstances, owing to the greater transverse strength of the wood.

The Black Hills have been subjected in the past to extensive forest-fires, which have destroyed the timber over considerable areas. Around Custer's Peak and along the limestone divide, in the central portion of the Hills, on the headwaters of the Box Elder and Rapid Creeks, scarcely a living tree is to be seen for miles. The timber, deadened by the fire and the trees left standing, their decaying trunks stripped of bark by weather or prostrated by the wind, cover the ground, crossing each other at all angles, forming an impassable abattis.

Some portions of the parks and valleys, now destitute of trees, show by the presence of charred and decaying stumps that they were once covered by forest, but generally the pine springs up again as soon as it is burnt off, though sometimes it is succeeded for a time by thickets of small aspens.

Along the eastern and northeastern slopes of the Black Hills, at a *distance of not more than* ten miles from the edge of the plains, the

pine is partly replaced by burr-oak and white elm of moderate size. These trees are found in groves in the valleys and swales between the hills, and associated with white birch in the ravines of the streams. Neither the oak nor elm attains a large size, the trees averaging 30 to 40 feet in height and 10 to 15 inches through.

The wood of the white elm is well known; that of the burr-oak resembles white oak, is strong and tough, and will prove valuable for many purposes.

In the elevated portion of the interior of the Hills, especially along the valleys in the limestone formation, extending from Custer's Peak to Floral Valley, and on the headwaters of Rapid, Castle, Elk, Bear, Butte, and Spearfish Creeks, two varieties of spruce, resembling the black and white spruce of the Northern States, are quite abundant. The trees are tall, growing thickly together, and will furnish logs quite uniform in diameter throughout their whole length. In the cañons where the soil is rich, the white spruce attains a height of 100 feet, and is occasionally 2 feet in diameter at the ground. Usually, however, these trees are from 8 to 15 inches through, and will prove very valuable in constructing trestles and small bridges on account of the strength of the timber. The wood is white, fine-grained, and remarkably tough and elastic. The small slender spruce-trees are much sought after by the Indians, who visit the Hills in the spring for the purpose of procuring them for lodge-poles.

It is difficult to estimate accurately the area covered by valuable timber in the Black Hills. Taking into consideration that the foot-hills are but sparsely wooded; that there are extensive parks and valleys in the interior destitute of trees, or where there are only scattered groves of pine; that over an aggregate area of several hundred square miles the timber has been destroyed by fire, I estimate that *one-half* the surface included within the timber-line is covered by forest of more or less mature growth.

By careful measurements of the map, the area within the timber-line, or outer boundary of the forest at the edge of the plains, is three thousand eight hundred square miles. One-half of this, or one thousand nine hundred square miles, is covered by woods, including the large forests of young trees, as well as the sections of valuable timber.

Portions of this area are difficult of access, or the timber is wind-shaken and injured in quality, and the forests of small pine are relatively more extensive than the tracts of timber of a mature growth. Hence I estimate that one-fifth the above area of the Black Hills, or nearly eight hundred square miles, equal to 500,000 acres, is covered by timber of merchantable quality, suitable for cutting and sawing into lumber.

Col. R. I. Dodge, commanding the escort, by an entirely independent series of observations, estimates the merchantable timber at only about four hundred square miles, and comparing it with the pine forests of North Carolina, he says:

> I estimate that there are in the two sections something over four thousand square miles of country more or less covered with pine. Of this, including the Red Valley, the parks, the bare bottoms and valleys of creeks, I estimate that four-tenths are entirely without timber. Another four-tenths is composed of young forests, excellent for railroad-ties, small buildings, fencing, &c., but not yet fit for the saw-mill. One-tenth is wind-shaken or injured by lightning or fire, and one-tenth is good lumber. In other words, I think that this four thousand square miles will furnish not more than one-tenth of the merchantable lumber that would be obtained from an equal area of the virgin pine forests of Michigan or North Carolina. There is an abundance of lumber for all purposes of the country itself, but, except ties, it will not furnish any very large quantity for exportation.*

* The Black Hills, by Richard Irving Dodge, lieutenant-colonel United States Army. *James Miller & Co., New York, 1876.* P. 102.